HYDRO-ELECTRIC INQUIRY COMMISSION

# ENGINEERING DATA

## THE QUEENSTON-CHIPPAWA POWER DEVELOPMENT

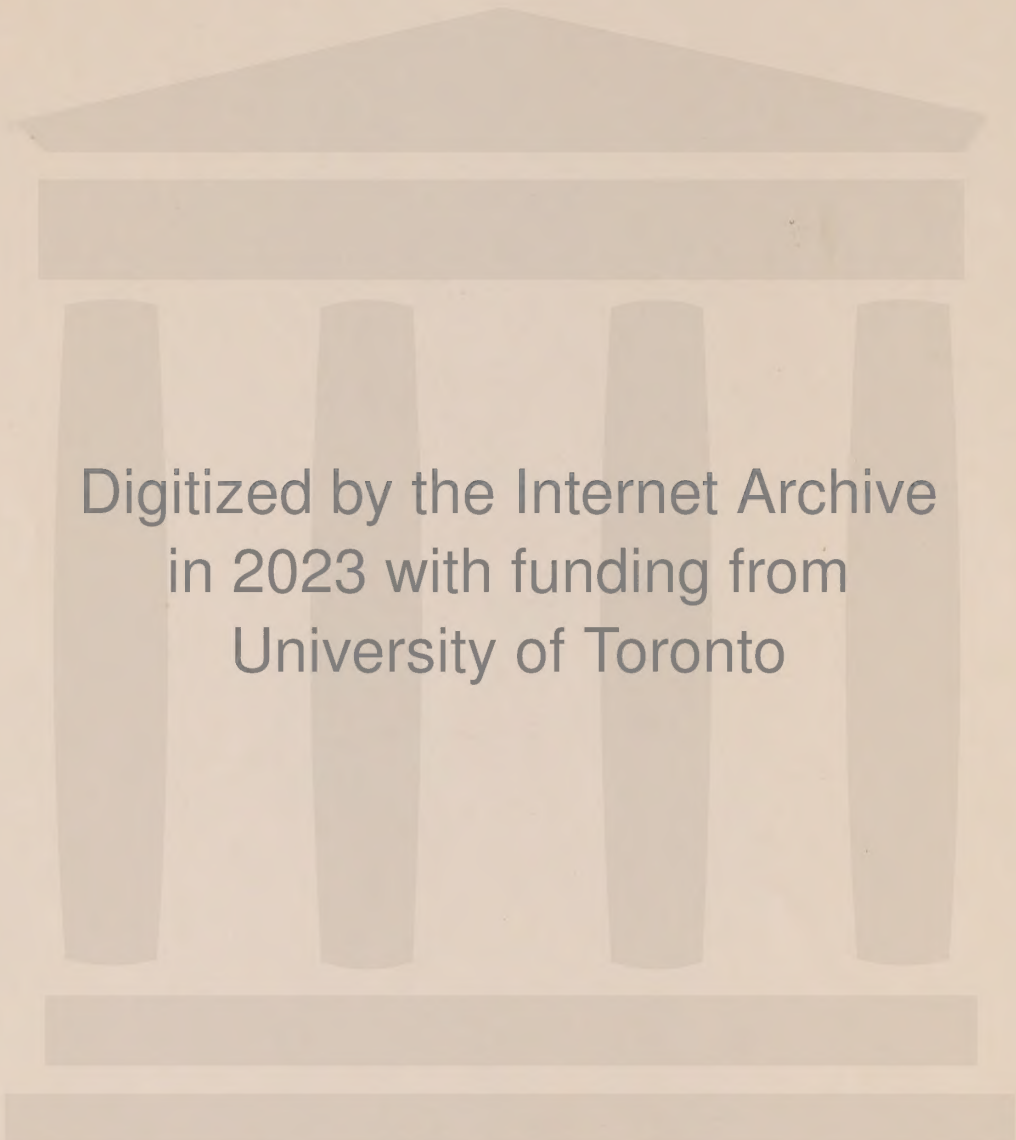
### CHAPTER "K"—COSTS

ANALYSIS OF ESTIMATES

PART II—APPENDICES

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS



Chapter K.

COSTS



(Analysis of Estimates)

Part II - Appendices

Walter J. Francis

Mr. J. Allan Hoss.

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Mr. J. Allan Rose.

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Chapter K.

COSTS

Walter J. Francis

The part of Chapter K called "Analysis of Estimates" is divided into two sections for convenience of reference. The first section contains the text. The second section is included herewith, and is composed of twenty-one appendices all referred to in the text above mentioned.



Walter J. Francis

Consulting Engineer.

Toronto, February 9th, 1923.

(Appendix I-a)

ESTIMATE No. 1.

Queenston-Chippawa Power Development

100,000 Horse-power Installation

Canal Project — Sheet 1

| Item | Quantity | Unit Price | Capital Cost | Maintenance and Dep. | Annual Cost |
|---|---|---|---|---|---|
| **Ice Fender at Mer Island** | | | | | |
| L. L. Pine | 13.2 M | $70.00 | 924 | 10 | 92 |
| Cedar | 24.0 M | 80.00 | 1,920 | 10 | 192 |
| Spruce | 2.75 M | 40.00 | 110 | 10 | 11 |
| Str. Steel | 45,957 lbs. | .05 | 2,297 | 4 | 92 |
| Bolts, etc. | 4,456 lbs. | .025 | 110 | 5 | 5 |
| Railing | 400 lin. ft. | 1.50 | 600 | 3 | 18 |
| Concrete Pins | 155 cu. yds. | 10.00 | 1,550 | 1/4 | 39 |
| Excavation | 550 cu. yds. | 1.60 | 880 | - | - |
| Unwatering, etc. (All for 300,000 H.P.) | - | - | 1,608 | - | - |
| | Sub-total | | $9,999 | | $449 |
| **Canal in Earth** | | | | | |
| Dredging | 1,125,000 cu. yds. | .20 | 225,000 | 1/8 | 281 |
| Right-of-way | 90 ac. | 150.00 | 13,500 | - | - |
| Fencing (All for 100,000 H.P.) | 3 miles | 150.00 | 480 | 10 | 48 |
| | Sub-total | | $238,980 | | $321 |
| **Control Works** | | | | | |
| Earth Excavation | 55,000 cu. yds. | .30 | 16,500 | 1/8 | 20 |
| Rock Excavation | 400 cu. yds. | 1.25 | 500 | - | - |
| Mass Concrete | 2,900 cu. yds. | 6.00 | 17,400 | 1/4 | 44 |
| Rein. Concrete | 139 cu. yds. | 15.00 | 2,085 | 1/4 | 5 |
| Stop Logs, etc. | 72 M | 70.00 | 5,040 | 10 | 504 |
| Piling, etc. | 4 M | 40.00 | 160 | 10 | 16 |
| Railing | 700 ft. | 1.75 | 1,225 | 3 | 37 |
| Miscellaneous | - | - | 1,000 | - | - |
| Unwatering | - | - | 515 | 1/4 | 1 |
| Flume Control (All for 300,000 H.P.) | - | - | 500 | - | - |
| | Sub-total | | $44,925 | | $627 |

ESTIMATE NO. 1. (continued)

Sheet 2

| Item | Quantity | Unit Price | Capital Cost | Maintenance and Dep. | Annual Cost |
|---|---|---|---|---|---|
| **Canal in Rock** | | | | | |
| Rock Excavation | 2,576,580 cu. yds. | 1.00 | 2,576,580 | - | - |
| Earth Excavation | 5,856,090 cu. yds. | .30 | 1,756,827 | 1/8 | 2,196 |
| Right-of-way | 280 ac. | 500.00 | 140,000 | - | - |
| Fencing | 7 miles | 150.00 | 1,050 | 10 | 105 |
| (All for 300,000 H.P.) | | | | | |
| | Sub-total | | $4,474,457 | | $2,301 |
| **Regulating Flume** | | | | | |
| Right-of-way | 140 ac. | 500.00 | 70,000 | - | - |
| Fencing | 7 miles | 150.00 | 1,050 | 10 | 105 |
| Cross Conduit | - | - | 12,000 | 1/8 | 15 |
| (All for 300,000 H.P.) | | | | | |
| | Sub-total | | $83,050 | | $120 |
| **Whirlpool Storage** | | | | | |
| Right-of-way | 16 ac. | 150.00 | 2,400 | - | - |
| Right-of-way | 22 ac. | 150.00 | 3,300 | - | - |
| Fencing | - | - | 2,400 | 10 | 240 |
| (All for 300,000 H.P.) | | | | | |
| | Sub-total | | $8,100 | | $240 |
| **Forebay** | | | | | |
| Earth Excavation | 63,000 cu. yds. | .25 | 15,750 | 1/8 | 20 |
| Rock Excavation | 547,000 cu. yds. | 1.00 | 547,000 | - | - |
| Mass Concrete | 6,000 cu. yds. | 6.00 | 36,000 | 1/4 | 90 |
| Right-of-way | 5 ac. | 500.00 | 2,500 | - | - |
| (All for 300,000 H.P.) | | | | | |
| | Sub-total | | $401,250 | | $110 |
| **Headworks Sub-structure** | | | | | |
| Rock Excavation | 32,000 cu. yds. | 1.25 | 40,000 | - | - |
| Mass Concrete | 10,000 cu. yds. | 6.00 | 60,000 | 1/4 | 150 |
| Rack Structure | 260,000 lbs. | .05 | 13,000 | 5 | 650 |
| Stoney Gates | - | - | 10,000 | 5 | 500 |
| (All for 300,000 H.P.) | | | | | |
| | Sub-total | | $123,000 | | $1,300 |

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(Appendix I-c)

ESTIMATE No. 1 (continued)

Sheet 3

| Item | Quantity | Unit Price | Capital Cost | Maintenance and Rep. | Annual Cost |
|---|---|---|---|---|---|
| **Headworks Super-structure** | | | | | |
| Brickwork | 100 M | 30.00 | $3,000 | 1/4 | 7 |
| Cut Stone | 500 cu. yds. | 15.00 | 7,500 | 1/4 | 18 |
| Steel | 360,000 lbs. | .05 | 18,000 | 4 | 720 |
| Concrete | 300 cu. yds. | 6.00 | 1,800 | 1/4 | 4 |
| Roof & Sundries (All for 300,000 H.P.) | - | - | 5,000 | 5 | 250 |
| | | Sub-total | $35,300 | | $999 |
| **Headworks Auxiliaries** | | | | | |
| Emergency Gate | - | - | 6,000 | 3 | 180 |
| Crane | - | - | 1,000 | 5 | 50 |
| Miscellaneous (All for 100,000 H.P.) | - | - | 1,500 | 5 | 75 |
| | | Sub-total | $8,500 | | $305 |
| **Ice Chute** | | | | | |
| Tunnel Rock | 500 cu. yds. | 5.00 | 2,500 | - | - |
| Concrete Lining | 250 cu. yds. | 15.00 | 3,750 | 1/4 | 9 |
| Open Trench Excava. | 840 cu. yds. | 1.25 | 1,050 | - | - |
| Open Trench Lining | 450 cu. yds. | 6.00 | 2,700 | 1/4 | 7 |
| Anchor Block | 16 cu. yds. | 6.00 | 100 | 1/4 | - |
| Stop Logs, Steel | - | - | 1,000 | 5 | 50 |
| Stop Logs, Wood | 1 M | 70.00 | 70 | 10 | 7 |
| Steel Lining | 100,000 lbs. | .04 | 4,000 | 5 | 200 |
| Fender | - | - | 1,000 | 5 | 50 |
| Cleaning Slope (All for 600,000 H.P.) | - | - | 6,000 | - | - |
| | | Sub-total | $24,170 | | $323 |
| **Penstock Shafts** | | | | | |
| Excavation 300,000 H.P. | 15,000 cu. yds. | 8.00 | 120,000 | - | - |
| Concrete Lining, 100,000 H.P. | - | 6.50 | 15,000 | 1/4 | 37 |
| Steel Lining, 100,000 H.P. | 800,000 lbs. | .05 | 30,000 | 4 | 1,200 |
| | | Sub-total | $165,000 | | $1,237 |

ESTIMATE NO. 1.(continued)

Sheet 4

| Item | Quantity | Unit Price | Capital Cost | Maintenance and Dep. | Annual Cost |
|---|---|---|---|---|---|
| **Penstock Tunnels** | | | | | |
| Excavation 300,000 H.P. | - | 5.50 | 66,000 | - | - |
| Concrete Lining 100,000 H.P. | - | 6.50 | 10,500 | 1/4 | 26 |
| Steel Lining 100,000 H.P. | 880,000 lbs. | .05 | 44,000 | 4 | 1,760 |
| Timbering | - | - | 10,000 | 5 | 500 |
| | | Sub-total | $130,500 | | $2,286 |
| **Exciter Penstock** | | | | | |
| Penstock Steel | - | .05 | 4,500 | 4 | 180 |
| Excavation | - | 1.50 | 4,000 | - | - |
| Concrete | - | 10.00 | 3,000 | 1/4 | 7 |
| Gates & Motor | - | - | 2,000 | 5 | 100 |
| Racks | - | .05 | 250 | 5 | 12 |
| (All for 600,000 H.P.) | | Sub-total | $13,750 | | $299 |
| **Power House Sub-structure** | | | | | |
| Excavation | 340,000 cu.yds. | .50 | 170,000 | - | - |
| Concrete | 18,790 cu.yds. | 8.00 | 150,000 | 1/4 | 375 |
| Unwatering | - | - | 20,000 | - | - |
| (All for 300,000 H.P.) | | Sub-total | $340,000 | | $375 |
| **Power House Super-structure** | | | | | |
| Superstructure 100,000 H.P. | - | - | 150,000 | 2 | 3,000 |
| Cranes, 600,000 H.P. | - | - | 100,000 | 4 | 4,000 |
| | | Sub-total | $250,000 | | $7,000 |

ESTIMATE NO.1. (continued)

Sheet 5

| Item | Quantity | Unit Price | Capital Cost | Maintenance and Dep. | Annual Cost |
|---|---|---|---|---|---|
| **Hydraulic Equipment** | | | | | |
| Main Turbines | 100,000 H.P. | 3.50 | 350,000 | 3 | 10,500 |
| Feeder Connections | - | - | 5,000 | 4 | 200 |
| Auxiliary Equipment | - | - | 75,000 | 5 | 3,750 |
| Exciter Turbine | 3,000H.P. | 8.00 | 24,000 | 4 | 960 |
| (All for 100,000 H.P.) | | Sub-total | $454,000 | | $15,410 |
| **Electrical Equipment** | | | | | |
| Main Generators | 100,000 H.P. | 5.50 | 550,000 | 4 | 22,000 |
| Exciter Generator | 3,000 H.P. | 9.00 | 27,000 | 6 | 1,620 |
| Switching, etc. | - | - | 200,000 | 2 | 4,000 |
| (All for 100,000 H.P.) | | Sub-total | $777,000 | | $27,620 |
| **Bridges** | | | | | |
| 10-ft. Farm Bridges | 7 | - | 27,000 | 5 | 1,350 |
| 16-ft. Highway Bridges | 7 | - | 30,000 | 5 | 1,500 |
| 20-ft. Highway Bridges | 1 | - | 6,000 | 5 | 300 |
| S.Tr. Railway Bridges. | 3 | - | 24,000 | 5 | 1,200 |
| D.Tr. Railway Bridges. | 1 | - | 26,000 | 5 | 1,300 |
| (All for 100,000 H.P.) | | Sub-total | $113,000 | | $5,650 |
| **Service Tunnel** | | | | | |
| Excavation | 4,200 cu.yds. | 4.00 | 16,800 | - | - |
| Lining & Partitions | 2,000 cu.yds. | 10.00 | 20,000 | 1/4 | 50 |
| Miscellaneous | - | - | 400 | - | - |
| (All for 600,000 H.P.) | | Sub-total | $37,200 | | $50 |
| Moving Poles, Towers, &c. | - | - | 15,000 | - | - |
| (For 300,000 H.P.) | | Sub-total | $15,000 | | |
| | | Total | $7,747,151 | | $67,022 |
| Engineering and Contingencies 25% | | | 1,936,787 | | |
| Total Carried Forward | | | $9,683,938 | | $67,022 |

ESTIMATE NO.1. (continued)

Sheet 6

| Item | Quantity | Unit Price | Capital Cost | Maintenance and Dep. | Annual Cost |
|---|---|---|---|---|---|
| Brought forward | | | $9,683,938 | ..... | $67,022 |
| Interest during construction, 7½% | | | 726,295 | | |
| Operation and Administration | | | | | 100,000 |
| Interest, 5% | | | | | 520,512 |
| Sinking Fund, 1.8% | | | | | 187,384 |
| Insurance and Sundries | | | | | 50,000 |
| Grand Total | | | $10,410,233 | | $924,918 |
| Cost per horse-power installed | | | $104.10 | ..... | $9.25 |



Basis of Estimate No.1.

1. - Protection against ice only at Chippawa, the lower channel between Hog Island and shore providing water when permanent work is placed for extension.

2. - No dredging in Welland River. Present section assumed sufficient.

3. - Dredge for 100,000 horse-power installation from Montrose to mouth of rock canal (about Station #84).

4. - Permanent control works at mouth of rock canal for 300,000 horse-power.

5. - Rock canal for 300,000 horse-power installed.

6. - Purchase full right-of-way for 300,000 horse-power.

7. - No regulating flume excavation.

8. - No artificial storage.

Basis of Estimate No.1. (continued)

9. - Highway and railway bridges built for extension at time flume is added, i.e., 300,000 horse-power.

10. - Forebay excavation for 300,000 horse-power.

11. - Sufficient excavation made in storage to provide safe location of concrete wall separating storage from canal.

12. - Retaining wall along International Railway where needed.

13. - Substructure for 300,000 horse-power installed at Head House.

14. - Superstructure for 300,000 horse-power installed at Head House.

15. - Cranes for all possible future purposes, i.e., 600,000 horse-power at Head House.



16. - Service tunnel, hot air, elevator and duct lines for 600,000 horse-power.

17. - One complete lined shaft and tunnel for 100,000 horse-power.

18. - Two shafts and tunnels excavated only for 300,000 horse-power.

19. - Ice shaft for 600,000 horse-power.

20. - Substructure and tail race for 300,000 horse-power.

21. - Exciter penstock and shaft for 600,000 horse-power.

22. - Superstructure for 100,000 horse-power - Power House.

23. - Hydro-electric installation for 100,000 including cranes for 600,000 horse-power.

24. - Towers and poles of power lines moved for 300,000 horse-power, etc.

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(Appendix II)

ESTIMATE No. 1.

Queenston-Chippawa Power Development

100,000 Horse-power and 200,000 Horse-power Installation

Canal Project January 5, 1916.

| Item | Cost 100,000 H.P. | | Cost 200,000 H.P. |
|---|---|---|---|
| Ice Fender | $ 9,999.00 | | |
| Welland River | | | $ 224,000.00 |
| Canal in Earth | 238,950.00 | ..... | 112,250.00 |
| Auxiliaries | 8,500.00 | ..... | 8,000.00 |
| Control Works | 44,925.00 | | |
| Canal in Rock | 4,474,457.00 | | |
| Regulating Flume | 83,050.00 | | |
| All Storage | 8,100.00 | | |
| Forebay | 401,250.00 | | |
| Headworks, Sub-structure | 123,000.00 | | |
| Headworks, Super-structure | 35,200.00 | | |
| Ice Chute | 24,170.00 | | |
| Penstock Shaft Excavation | 120,000.00 | | |
| Concrete Lining | 15,000.00 | ..... | 15,000.00 |
| Steel Lining | 30,000.00 | | |
| Excavation Penstock Tunnel | 76,000.00 | | |
| Concrete Lining | 10,500.00 | ..... | 10,500.00 |
| Steel Lining | 44,000.00 | ..... | 44,000.00 |
| Exciter Penstock | 13,750.00 | | |
| Power House Sub-structure | 340,000.00 | | |
| Power House Super-structure | 250,000.00 | ..... | 175,000.00 |
| Hydraulic Equipment | 454,000.00 | ..... | 400,000.00 |
| Generators | 577,000.00 | ..... | 600,000.00 |
| Switching | 200,000.00 | ..... | 200,000.00 |
| Bridges | 113,000.00 | ..... | 220,000.00 |
| Service Tunnel | 37,200.00 | | |
| Moving Poles | 15,000.00 | | |
| Total | $ 7,747,151.00 | ..... | $2,038,750.00 |
| Engineering and Contingencies - 25% | 1,936,787.00 | ..... | 509,687.50 |
| Total | $ 9,683,938.00 | ..... | $2,548,437.50 |
| Interest during Construction - 7% | 726,295.00 | ..... | 191,132.80 |
| Add for 100,000 H.P. additional | - | | 10,410,233.00 |
| Grand Total | $10,410,233.00 | | $13,149,803.30 |

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(Appendix III-a)

ESTIMATE NO. 2.

Queenston-Chippawa Power Development

Summary of Estimated Quantities and Cost
300,000 Horse-power Installation

Canal Project — Revised November 27, 1917.

| | | | | |
|---|---|---|---|---|
| Intake | | | | $ 973,700.00 |
| Canal | - Welland River Division | | $ 533,384.00 | |
| | Earth Division | | 1,535,603.00 | |
| | Transition Earth to Rock | | 47,168.00 | |
| | Rock Division No. 1 | | 4,328,165.00 | |
| | Transition Rock to Whirlpool | | 47,646.00 | |
| | Whirlpool Division | | 715,002.00 | |
| | Transition Whirlpool to Rock | | 53,120.00 | |
| | Rock Division No. 2 | | 885,234.00 | |
| | Forebay | | 399,874.00 | |
| | Right-of-way | | 600,000.00 | 9,145,196.00 |
| Bridges | - Highway | | 293,203.00 | |
| | Railway | | 317,120.00 | 610,323.00 |
| Gate House | - | | | 360,708.00 |
| Penstocks | - Exciter Penstock | | 18,530.00 | |
| | No. 1 | " | 63,158.00 | |
| | No. 2 | " | 63,585.00 | |
| | No. 3 | " | 63,438.00 | |
| | No. 4 | " | 66,000.00 | |
| | No. 5 | " | 66,150.00 | |
| | No. 6 | " | 68,325.00 | 409,236.00 |
| Power House | - Substructure | | 969,850.00 | |
| | Superstructure | | 690,300.00 | 1,660,150.00 |
| Hydraulic Equipment | | | | 1,768,000.00 |
| Electrical Equipment | | | | 3,250,000.00 |
| Miscellaneous | | | | 175,000.00 |
| | | | | $18,352,313.00 |
| Engineering and Contingencies - 25% | | | | 4,588,078.00 |
| Interest During Construction - 7% | | | | 1,376,424.00 |
| | | | | $24,316,815.00 |

Note: Earth Excavation estimated at 27 cents per cubic yard.
Rock Excavation estimated at 98 cents per cubic yard.

(Appendix III-b)

Queenston-Chippawa Development Project.

Detailed Report on Canal Scheme, together with Discussion of Alternative Schemes of Development, with Estimates and Final Conclusions.

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GOVERNING CONDITIONS.

The preliminary and ultimate scope of the Niagara Development project must be considered in connection with the following limiting and governing conditions.



1. Boundary Waters Treaty - Under the terms of Article V. of the Boundary Waters Treaty the diversion of water from the Niagara River for power purposes is limited to diversion from the actual channel of the river above the Falls.

2. Contractual Limitations - The agreement of 1892 between the Park Commissioners and the Canadian Niagara Power Company stipulates that no other parties shall have the right to use the water of the Niagara River for power purposes within the park limits, and that the Commissioners themselves shall not use the water in question for power purposes except for the requirements of the park. The agreement of 1899 between the same parties eliminates the monopoly clause and simply stipulates that the Commissioners themselves shall not use the water except for park purposes.

This latter clause is also incorporated in the Electrical Development

Company agreement of 1903.

In both of the above agreements the work "Park" wherever used, is defined as meaning the park "proper" within its original limit south of the Clifton House.

Both of the above agreements also cite the Park Commissioners as acting on behalf of the Province of Ontario.

It appears therefore that the Park Commissioners, as representing the Province of Ontario, cannot make use of park lands or riparian rights within the original limits of the park for any purpose connected with the development of power for general sale and distribution.



5. Maximum Head - On the assumption that the waste of power resulting from the present policy of using only a portion of the available head will no longer be tolerated, any scheme for future development must embrace the most effective possible utilization of the total difference in level between Lake Erie and Lake Ontario.

4. Adaptability for Extension - Assuming that the 500,000 horsepower or more now being wasted by the existing partial head development at Niagara and on the Niagara Peninsula, must be reclaimed in the not distant future, any new scheme involving the immediate use of such surplus of treaty water as is now available, must be so laid out that it can be effectively and economically extended to embrace the ultimate use of the total present treaty allotment of 36,000 second feet and also the surplus water available from the Welland Canal System.

5. Maximum Degree of Advantageous Use of Water - The rate at which

the Niagara power is now being absorbed on both sides of the boundary indicates that the time will inevitably come when the present treaty limitations must be removed, and both countries will divert every drop of water that physical conditions will permit. When this phase of development is reached, power will be so valuable that the installation of plant will no longer be based solely upon the continuous capacity obtainable under minimum flow conditions, but instead the fullest possible use must be made of large quantities of power over and above the minimum which will be periodically available during the higher stages of outflow from Lake Erie.

6. Capital Cost - Inasmuch as the ultimate demand for Niagara power will be primarily governed by the maximum amount of power capable of being produced, rather than by the cost per horse-power, the final choice of any one scheme of development, as between several physically feasible schemes, should not be influenced by the question of capital cost to any greater extent than to assure the possibility of selling the product of the preliminary installation at prices which will effectively meet competition, not only from other sources of hydraulic power, but from power produced by steam, oil and gas. Beyond this limitation, any moderate difference in capital cost should be disregarded in considering the merits of different schemes.



A block of power delivered to the switchboard at Niagara is of no real value to the Province apart from the value of the comforts, conveniences and commodities which this power can produce for the welfare of the individual citizen. The influence of Niagara power upon the wealth and prosperity

(Appendix III-e)

of the Province will therefore be measured by the maximum amount of power which can be ultimately produced and effectively utilized, and any scheme of development adopted should be that which conforms to this fundamental requirement to the greatest degree, within practicable limits of capital cost.

SCHEME OF DEVELOPMENT.

Condition 1, 2 and 3 above noted may be assumed to preclude the consideration of any scheme of development involving the diversion of water from the Niagara River below Chippawa or above Port Erie.



Condition 4 naturally suggests using the natural channel of the Welland River to exercise the joint function of drawing water from the Niagara River and from the Welland Canal System.

This in turn leads to the consideration of connecting some point on the Welland River with Lake Ontario level by such type of artificial waterway as would best conform to the requirements 5 and 6. The choice of artificial waterway lies between an open canal and a pressure tunnel, preference being on the side of the open canal on account of its being naturally better capable of meeting the paramount conditions with regard to maximum utilizible capacity.

A preliminary investigation in the field, based upon the above premises, indicated the practicability of connecting a point on the Welland River about four miles west of its mouth, with a point on the Niagara River a short

distance above Queenston, the natural difference in level between these two points being normally about 315 feet.

An extensive series of surveys and borings was accordingly made which finally resulted in the laying out of the scheme of development shown on appended Plan "A". This scheme consists essentially of an intake structure at the mouth of the Welland River, the deepening of the natural channel of the Welland River to a point about four miles west of its mouth, and from thence an excavated canal 8.6 miles in length, to a forebay location on the edge of the gorge, a short distance above Queenston, from which point the water will be carried through steel penstocks to the turbines, which will be located in a power house in the bottom of the gorge.



Having in view the large and growing demand for power on the Niagara System, and the economy resulting from the installation of generating units of large capacity, it was decided to consider the installation of units of 50,000 H.P. capacity, and all studies in connection with the Queenston-Chippawa Development Scheme have been made upon that basis.

All preliminary studies in connection with this scheme were also based upon making the most efficient and economical use of the estimated surplus of 6,500 second feet of treaty water then considered available.

CANAL DESIGN.

The most vital feature of the installation as a whole was the design of the canal, and something over a year's time was consumed in an exhaustive study of this problem, which was finally solved by a more or less original

method of attack.

In October 1916 all data, calculations and studies in connection with the design of the canal were submitted to Mr. H. H. Johnson, Consulting Engineer, of New York City, for criticism and check.

Under date of February 1st, 1917, after four months of investigation, Mr. Johnson submitted his report which is appended hereto as Appendix 1.

Mr. Johnson's method of attacking the problem was essentially identical with the original method developed by the Commission Engineers, but he was able to introduce some refinements into his calculations which gave his final figures a somewhat greater degree of accuracy. In the case of the rock section of the canal, Mr. Johnson's figures indicate the advisability of fixing the low water velocity at six feet per second, and of so altering the width and depth of the section as to materially reduce the head loss at the expense of a slight increase in the amount of excavation.



Subsequent to the receipt of Mr. Johnson's report, the taking over of the Ontario Power Company interest by the Commission gave rise to the possibility of being able, within a reasonable time, to make use of 10,000 second feet of water in place of the 6,500 second feet previously considered available. The canal was therefore entirely re-designed for 10,000 second feet in accordance with Mr. Johnson's refined method, and in general accordance with the recommendations made by him in connection with the 6,500 second feet canal.

The discussion and analysis of the design of the 10,000 second foot canal is set forth in detail in Appendix 2.

CONSTRUCTION METHODS.

A careful study of construction methods in connection with the excavation of earth and rock in the canal was necessary by reason of certain existing conditions which would have a vital influence upon excavating cost. These conditions were, first, the availability of cheap electric power for operating construction plant; second, the large quantities of earth and rock to be removed, which made it possible to consider the use of excavating machinery of the heaviest type and largest capacity obtainable; and third, the unusually good facilities available for the disposal of spoil, within short hauling distance, along the crest of the Niagara escarpment.



Having the above conditions in mind, the Commission's Engineers spent several months in collecting and studying data in connection with the type of construction plant required. The operation of electric and steam driven excavating machinery was witnessed and studied in various parts of Canada and the United States and a large amount of information with reference to output, operating cost, working conditions, etc. was obtained and carefully analyzed.

The result of this investigation was, that in January 1917, when market conditions indicated that any further delay in the purchase of the plant would result in prohibitive prices and practically impossible delivery dates, the Commission's Engineers were immediately able to recommend for purchase the type of plant best suited for carrying on the projected work.

Practically all of the plant so purchased is now on the ground and a portion of it is in actual operation.

A detailed description of the construction plant, with views of portions of the same, is attached hereto under Appendix 3.

PROGRAMME OF OPERATIONS.

As the time necessary to complete the construction of the canal was considered to be the limiting factor in connection with the date of first delivery of power from the completed plant, this portion of the work was divided into four separate divisions for efficient administration and supervision, the details under this head being set forth in Appendix 4.

Careful consideration was also given to the sequence of operations in the various divisions so as to provide for the most efficient and economical means of carrying on the work, and to insure the earliest possible date of completion. The proposed programme of operations is set forth in detail in Appendix 5.



The progress schedule for the installation as a whole is set forth in Appendix 6. In connection with this schedule it will be noted that the date of final completion of work is October 1921, the canal being the limiting factor as above stated. When the 6,500 second foot canal project was under consideration it was estimated that the work could be completed by December 1920, and the construction plant was laid out and purchased on this basis. The extra ten months of time now estimated to be necessary to complete the work is due to the increased quantity of earth and rock excavation involved in the construction of the 10,000 second foot canal.

In working out this schedule the daily output of the excavating plant has been conservatively estimated according to the manufacturers' specifications, and futhermore, the estimated yearly output has been based upon 250 full working days, whereas with the electrically operated plant 300 full working days can reasonably be expected. In view of these facts, there is reasonable ground for hope that the date of completion may be materially advanced, and this hope will become a practical certainty if sufficient labour is available to handle two ten hour shifts to be operated continuously. This latter condition is not a desirable one from the standpoint of efficiency, and better and more economical results could be obtained by putting in additional excavating plant on day shift, and reducing night work to a minimim.



CAPITAL COST.

As regards estimates of capital cost, it is to be noted that the tremendous advance which has taken place during the period of the war in the cost of labour and material has necessitated a very material increase in all estimates made during the pre-war period. Fortunately, for reasons hereunder explained, this statement does not hold for the two main items of cost in connection with the scheme as a whole; namely, the cost of earth and rock excavation in the canal. Lacking definite knowledge, at the time, as to the extent to which the cost of rock and earth excavation in the canal would be affected by the use of the electric driven plant of large capacity, and in order to be on the safe side, all the earlier

estimates of cost in connection with the canal work were figured on the basis of unit costs for earth and rock excavation which would obtain if the ordinary type of steam driven excavation plant were used. On the basis of this assumption a net unit cost of 30¢ per cubic yard of earth and $1.00 per cubic yard for rock was used in all preliminary estimates.

Owing to the fact that the construction plant has been purchased, and that construction work is now under way, it has recently been possible to compile an estimate of the unit cost of earth and rock excavation which is based on the actual installed cost of the construction plant, the actual existing rates for skilled and common labour, and a reasonably accurate knowledge of working conditions.



A detailed discussion and analysis of the cost of operating this plant, with corresponding costs per cubic yard of excavation, is set forth in Appendix 7.

The final figures for the net unit cost of earth and rock excavation as indicated by the above analysis may be considered as authoritative, and the safe basis upon which they have been derived is indicated by consideration of the following facts.

The main factor affecting unit cost is the volume of the output of excavated material. This output has been figured on the basis of a season of 250 working days, whereas, in view of the fact that electric operated excavating plant is largely independent of weather conditions as regards continuous operation, a season averaging not less than 300 working days can be anticipated.

All interest, depreciation and repair charges on construction plant are figured on a yearly basis, but the resulting unit costs are charged against 250 working days only in each year.

The disposal costs are figured on the basis of an average haul of six and one-half miles, which is considerably in excess of the average haul which will obtain under actual working conditions. An ample margin of safety is thus provided for in the matter of prompt and continuous train service for the efficient handling of excavated material.

Eighty-six per cent of the cost of all track and overhead construction has been charged direct into the unit cost of earth and rock, leaving a salvage value which is less than the ordinary market value of the reclaimable material entering into this portion of the construction.



In addition to a final 25% allowance for engineering and contingencies, a liberal allowance for administration and other overhead charges has been previously included in the individual items of the cost analysis.

The final result of this analysis is to show that earth and rock can be taken out for a net unit cost of 26.8¢ per yard and 97.3¢ per yard respectively, as against the unit prices of 30¢ per yard and $1.00 per yard used in the original estimates.

It becomes evident therefore that by reason of the greatly increased efficiency of the plant to be used, as compared with ordinary construction plant, and the cheapness of electric power as compared with steam generated power, it will be possible to take earth and rock out of the canal at the present time as cheaply as it could have been taken out with the ordinary

type of steam driven plant under pre-war conditions.

As a matter of comparison, an estimate has been made of the probable cost of taking out earth in the canal under present conditions, using steam operated plant of the type which gave the best results in earth work on the Welland Canal. The details of this estimate are set forth in Appendix 8. It shows that under such conditions it would cost about 43¢ net per yard to take earth out of the canal with steam operated plant, as compared with 26.6¢ net per yard with electric operated plant.

Similar comparative figures have not been derived for rock excavation, but in Appendix 9 will be found a comparison of the cost of operating compressor plant by steam and by electric power. This estimate shows that the cost of producing the compressed air necessary for taking out the rock in the canal would be more than double what it will cost when produced by electric power.



In Appendix 10 is set forth the details of a recently compiled estimate of capital cost covering the 10,000 second foot canal and the installation of 300,000 electric horse-power complete, in units of 50,000 horse-power each.

In compiling the above estimate proper consideration has been given to recent and probable future advances in the cost of machinery, labor and materials, and each separate item of the estimate has been figured on a safe basis in regard to quantity and unit cost. Finally, to the total thus derived, an allowance of 32½% has been added for engineering and contingencies and interest during construction, making in all a gross total of $24,217,000.00

for 300,000 electrical horse-power installed.

In Appendix 10 is also set forth the details of estimates covering the preliminary installation of 200,000 E.H.P. and 150,000 E.H.P. respectively. Both of these latter estimates include the total capital cost of those portions of the permanent works for 300,000 H.P. which must of necessity be constructed as part of the preliminary installation, whatever its capacity may be.

The general scheme of construction upon which the various above estimates were based is covered in Appendices 3, 4, and 5 and Plans referred to therein, together with attached Plans "F" and "G" showing a typical cross-section of the forebay and power house, and the proposed intake works at the mouth of the Welland River, respectively.



ALTERNATIVE SCHEMES OF DEVELOPMENT.

Supplementary Reports - In the opening paragraph of Mr. Johnson's report of February 1st (Appendix I) he states that the report in question does not contain any criticism of "the larger questions of judgment which have determined the choice of a canal instead of a tunnel". This statement appeared to indicate, on his part, a disposition to doubt the wisdom of adopting the open canal type of waterway in preference to a pressure tunnel, and to clear up any element of uncertainty which might exist in this regard, it was thought advisable to give Mr. Johnson an opportunity to submit his ideas in a supplementary report, which he was accordingly requested to prepare.

At the same time it was considered advisable to have the opinion of an experienced contracting engineer with regard to the practical construction features of the problem, and the comparative costs involved. This commission was intrusted to Mr. A. C. Douglass, Contracting Engineer, of Niagara Falls, N.Y.

Mr. Douglass was qualified to report authoritatively with regard to this matter on account of his wide and varied experience in rock and tunnel work, and more particularly so because he built the tailwater tunnels at Niagara Falls for the Niagara Falls Power Company, Canadian Niagara Power Company, and the Electrical Development Company.



Mr. Johnson's supplementary report, together with a series of comments upon the same, is attached hereto as Appendix 11.

Mr. Douglass' report is attached hereto as Appendix 12. Before submitting his report, Mr. Douglass laid the conditions of the problem before several of the large engineering and contracting firms in New York who have had to do with the construction of the various tunnels under the Hudson River. The opinions of these parties, expressed in letter form, are attached to Mr. Douglass' report.

The general layout of the Tunnel Scheme as considered by Messrs. Johnson and Douglass, is shown on Plan "H" herewith.

Along with the tunnel scheme proper, consideration was given to a scheme of development involving the combined use of an open canal and a pressure tunnel. The general layout of this proposition is shown on Plan "J" attached, and consists essentially of a short section of open canal from the

mouth of the Welland River to the present forebay of the Ontario Power Company, from which point a pressure tunnel is carried two and a half miles to a point west of the city limit of Niagara Falls, and from that point an open canal for the remainder of the distance to the forebay location above Queenston.

This proposition will be referred to hereafter as the "Combined Scheme".

General Considerations - Both the tunnel scheme proper and the combined scheme involve the construction of works within the limits of the park, thus bringing these projects into conflict with the franchise rights of the power companies now operating on the Canadian side within the park limits.



Neither of the schemes in question can make effective use of such surplus water as may in the future become available from the Welland Canal System.

In the case of the combined scheme, the upper section of the canal and the works at the tunnel entrance might be looked upon as being undesirable features as related to the preservation of the natural beauty of the Falls, and any extension to this scheme of development would greatly intensify this objection.

Head Water Levels and Gross Head - All three schemes of development have a common point of intake at Chippawa, and a common point of delivery above Queenston, so that they are all on the same footing as regards available gross head, and are subject to the same variations of head-water level.

Since 1902 the water level at Chippawa has been observed twice daily, and on the basis of the mean daily level for this fifteen year period, a

duration curve, Plate I attached, has been compiled.

This curve shows that the mean level for the fifteen year period is slightly in excess of elevation 560.5.

It also indicates the following facts. -

1. A water level elevation 559 or higher obtained for 99.87 per cent of the entire period, and only on seven days throughout the fifteen years did the water level fall below this elevation.

2. Water level elevation 561 or higher obtained for 33.49 per cent of the entire fifteen year period.

3. The recorded absolute minimum level is elevation 558.5. This is an abnormal condition probably resulting from the combination of a natural low-water period and an up-lake gale.



4. The recorded absolute maximum level is elevation 563.0. This maximum has no practical significance, as it obtained for so short a period that no effective advantage could have been taken of it, in connection with the production of power.

For practical purposes, it may be assumed that the effective range of levels at the common intake lies between elevations 559 and 561.

Comparative Head Losses - Plate II attached, indicates graphically the head losses chargeable against the various schemes of development as now laid out, for various head water levels at Chippawa.

It will be noted that two curves have been plotted for the canal head losses, one curve on the basis of no ice cover on the Welland River Division of the Canal, and one curve on the assumption of one foot of ice cover over the entire Welland River Division. This latter curve has little practical

significance apart from indicating what would happen by reason of the occurrence of a most improbable condition, which, as a matter of fact, can be eliminated completely for a trifling annual expenditure. Under prevailing winter conditions on the Niagara Peninsula, and with the prevailing operating velocity in the river section, there will be very few days in each winter season when ice will be able to form at all, and then in such small quantities that it can be effectively and inexpensively removed.

Comparing the head losses in the canal, without ice cover, with those of the other two schemes, it is seen that the canal has a consistent advantage over the tunnel and combined schemes throughout the full effective range of head water levels at Chippawa, between elevations 559 and 561.



Under normal minimum conditions, without ice cover, the canal will produce, from 10,000 second feet of water, about 1800 horse-power more than the combined scheme, and about 5,000 horse-power more than the tunnel scheme.

Under mean conditions, the canal will similarly produce about 3200 horse-power more than the combined scheme, and about 6500 horse-power more than the tunnel scheme.

With Chippawa level at elevation 561 or over, the canal will similarly produce about 2500 horse-power more than the combined scheme, and about 7000 horse-power more than the tunnel scheme.

Under extreme minimum conditions, and with one foot of ice cover on the Welland River Section, the canal will produce about 4000 horse-power less than the combined scheme, about 600 horse-power less than the tunnel scheme, and about 1100 horse-power less than the 300,000 horse-power for which the

plant is designed. Even assuming that such a condition is not entirely preventable, in the case of the canal scheme, this deficiency in capacity could only have obtained in varying degree for a short time of five separate days during the last fifteen years, the actual dates upon which this condition might possibly have obtained being as follows - Feb.6/11 - 559.6; Feb.14/11, 558.7; Feb. 21/12, 559.9; Feb. 2/15, 558.9; Dec. 29/15, 558.6.

Under mean water level conditions at Chippawa the canal scheme would deliver about 30.8 horse-power, the combined scheme about 30.6 horse-power, and the tunnel scheme about 30.2 horse-power per second foot of water delivered at the forebay. These figures constitute the ultimate test of the comparative economic efficiencies of the three schemes of development under consideration.



Comparative Carrying Capacity - The discharge capacity curves, Plate III attached, illustrate concisely the comparative characteristics of the three types of waterway under mean water level conditions at Chippawa.

Comparing the canal discharge with that of the tunnel, it will be seen that when the forebay level has been drawn down to elevation 526 the canal will have practically reached its maximum discharge capacity, whereas by continuing to pull down the forebay level the discharge of the tunnel can be still further increased. It is only permissible to utilize this characteristic of the tunnel type of waterway, however, when the abnormal loss of head involved can be compensated for by drawing upon a more or less unlimited supply of water. This principle is utilized to great advantage in connection with private power enterprises, and its use is well illustrated in the case of the tailwater tunnel of the Electrical Development Company. Out of a total available head of about 186 feet, this Company wastes between 30 and 40 feet in its tailwater tunnel, this

waste of head necessitating a correspondingly excessive diversion of water from the river in order to develop the 125,000 electric horse-power permitted under the terms of its franchise.

Such wasteful use of public asset cannot be considered in connection with a public enterprise like the Queenston-Chippawa Development Scheme. This phase of the question is also discussed in the comments on paragraph 20 of R. D. Johnson's report of April 18th, 1917. See Appendix No. 11.

Comparing the canal and combined schemes, reference to Plate III will show that the discharge of the combined tunnel and canal waterway practically reaches its maximum when the forebay level has been drawn down to elevation 538, and furthermore that the discharge of the open canal for any equivalent forebay level, is on the average about 800 second feet greater than that of the combined waterway. At forebay elevation 550, the open canal would deliver to the forebay 30,000 horse-power more power than the combined waterway, and at the forebay elevation 544 the advantage on the side of the open canal would amount to about 21,000 horse-power. The proportionate advantage on the side of the canal scheme based on the ultimate use of 36,000 second feet, would be from 75,000 to 108,000 horse-power.



Stating the above proposition in another way, the canal, with forebay level at elevation 550, will deliver 1165 horse-power per foot of head as against 1065 horse-power per foot of head in the case of the combined waterway, and approximately 900 horse-power per foot of head in the case of the tunnel.

The above figures illustrate the outstanding disadvantageous features of the combined waterway as against the open canal on one hand and the tunnel on the other. The tunnel portion of the combined scheme prevents this waterway as

a whole from exercising the important function of an open canal in the matter of utilizing water which is available during the higher stages of water level at Chippawa, while, on the other hand, the sections of open canal at the upper and lower ends of the combined waterway prevent it from exercising the function of the tunnel type of waterway in the matter of utilizing a large volume of flow at the expense of effective head.

The above point is more fully brought out in the curve on Plate IV attached. These curves show the discharge capacities of the three types of waterway for different forebay levels with water level at Chippawa standing at elevation 561.

Comparing the discharge curves for the open canal and the combined tunnel and canal waterway, it will be seen that at forebay level elevation 550 the open canal will deliver 1,040 second feet more water than the combined waterway. Similarly at forebay elevation 544 the open canal will deliver 800 second feet more water than the combined waterway. In other words, at the respective forebay elevations above mentioned the open canal will deliver 52,000 horse-power and 24,000 horse-power more power to the forebay than the combined waterway. Increasing these latter quantities in direct proportion, it would mean that in the event of the ultimate diversion of the whole of the present treaty allotment, the open canal scheme of development would deliver from 85,000 to 115,000 horse-power more power to the forebay at Queenston than the combined waterway scheme, whenever the water level at Chippawa stood at elevation 561 or above.



Ice Conditions - The common point of intake for the three schemes of development above considered is the mouth of the Welland River, which is situated in the deepest part of a pronounced depression in the shoreline of the Niagara River. This depression extends from Slater's Point, opposite Navy

Island, to a point a short distance above the first break of the upper rapids. The result is that ice passing down the channel between Navy Island and the Canadian shore is carried by the strong current well out into the Grass Island pool, to such a distance that the ice floes clear the mouth of the Welland River by a thousand feet or more under ordinary conditions, and do not approach the shore until they reach a point in the vicinity of the Ontario Power Co. intake. This fact has been amply confirmed by observation, and it is only very occasionally, during the period of a northerly or north-easterly gale, that any ice is forced into the depression above described, or into the mouth of the Welland River.



As regards freedom from ice trouble, therefore, the mouth of the Welland River offers the best natural intake facilities of any location on the river on either side of the boundary.

Under such conditions, it will be possible to design an intake structure which will keep the diverted water practically free of ice, and in the case of the open canal, any ice which may find its way through the intake works can be handled in the open and disposed of either through the ice sluice at the intake or the ice sluice at the lower forebay. Even should a comparatively large quantity of ice find its way into the canal, it can be disposed of without any serious hazard as regards continuous plant operation.

In the case of the tunnel scheme of development, even small quantities of ice and debris passing through the intake works would constitute a serious menace, as such material would tend to lodge in the tunnel and gradually build up an obstruction, the clearing away of which might necessitate a total shutdown and the unwatering of the tunnel. This matter has been discussed in the

comments on paragraphs 19 and 33 of Mr. Johnson's report of April 18th, 1917, Appendix No.11.

In the case of the combined scheme, reference to Plant "J" will show that in addition to the ice sluiceway provided at the intake, a supplementary ice sluiceway has been provided for at the lower end of the upper section of canal, where the water enters the tunnel. There is a head of several feet on this lower sluiceway and the high relative velocity through the same offers a very effective means of disposing of such ice as may have found its way through the intake works and past the upper sluiceway. If it is assumed that the intake works, in conjunction with the favorable natural conditions, will not be effective in preventing ice trouble, the means of secondary disposal offered by the combined scheme is an important feature which distinguishes it favorably from the other two schemes of development, but this possible advantage is far outweighed by the previously mentioned disadvantage which this scheme possesses as compared with the other two schemes of development.



Comparative Capital Cost - In the estimates of cost for the canal scheme, Appendix 10, the cost of earth and rock excavation was figured on the basis of the detailed cost analysis set forth in Appendix 7.

The earth and rock costs in connection with the canal portion of the combined scheme will be discussed hereunder on the same basis, after making such adjustments in the unit costs as are necessary by reason of the smaller yardages and the less favorable working conditions.

The capital cost of the tunnel scheme has been figured on the basis of the detailed costs and recommendations set forth in Mr. Douglass' report, Appendix 12.

In connection with Mr. Douglass' report, it will be noted that he has also reported on the probable unit cost of earth and rock excavation in the canal. His price for earth is essentially the same, but his price for rock is about 25% higher than that derived from the cost analysis above mentioned. Mr. Douglass states in his report that these figures are based on his previous experience with steam driven plant, and upon information that he has received from work now being done with such plants, so that his figure for earth should properly be compared with the net estimate of 43.9 cents per yard as covered by Appendix 8. If the cost of rock excavation were increased in the same proportion, it would make the net cost of excavating rock with steam driven plant about $1.60 per yard, which figure would compare with Mr. Douglass' estimate of $1.56 per yard.



The same explanation applies as regards the estimated figures given for the cost of earth and rock excavation in the canal in the reports of the Rapid Transit Subway Construction Co., H. L. Cooper & Company, and P. McGovern and Company, as appended to Mr. Douglass' report.

In connection with the tunnel costs, it will be noticed that Mr. Douglass' figures are lower than those specified by the New York Engineers whom he consulted. In view, however, of Mr. Douglass' wide experience in this kind of work, and his unequalled knowledge of tunnel construction in the vicinity of Niagara Falls, his figures have been accepted as authoritative and have been used in the tunnel scheme estimates.

Estimates of the cost of the tunnel scheme for 300,000, 200,000 and 150,000 horse-power respectively are set forth in Appendix 13.

Estimates for the combined tunnel and canal scheme for 300,000, 200,000

and 150,000 horse-power respectively are set forth under Appendix 14. In this case also the cost of the tunnel section is based on Mr. Douglass' figures.

In the case of the combined scheme, there is some doubt as to whether the tunnel section would require to be timbered throughout, and a note is appended to each of the estimates in connection with this scheme showing to what extent the capital cost would be reduced if only 50% of the tunnel should require timbering.

The salient facts in connection with the estimates on the three schemes under consideration are briefly summarized in the tabulation hereunder,-



| Capacity | Tunnel Single Intake | Tunnel Double Intake | Combined Scheme All timbered | Combined Scheme 50% timbered | Open Canal. |
|---|---|---|---|---|---|
| 300,000 H.P. | $31,006,000 | $29,736,000 | $25,539,000 | $24,913,000 | $24,317,000 |
| 200,000 H.P. | 27,977,000 | 26,706,000 | 22,560,000 | 21,934,000 | 21,026,000 |
| 150,000 H.P. | 26,297,000 | 25,028,000 | 20,896,000 | 20,270,000 | 18,986,000 |

The above figures show, in the first place, that the tunnel scheme is not comparable in any way with the other two schemes, from the standpoint of capital cost, the balance in favor of the canal ranging from $5,000,000 to $7,000,000.

As regards the other two schemes, the figures indicate that the combined scheme will cost at least $600,000. more than the canal scheme on the basis of full capacity, with a still greater balance in favor of the canal on the preliminary installations. If the tunnel section of the combined waterway should require to be timbered throughout the canal scheme would be the cheaper by about $1,200,000 for the total installation, and $1,900,000 for a preliminary

150,000 H.P.

It would appear therefore that in addition to being the superior of the other two schemes of development as an effective producer of power, the canal scheme is actually cheaper from the standpoint of actual capital cost, by amounts ranging between $600,000 and $7,000,000.

GENERAL CONCLUSIONS.

The conclusions arrived at as a result of the above discussion are,-

That, having regard to the paramount consideration of conserving to the utmost, in the public interest, the priceless power resources of Niagara, the open canal scheme of development has a real and decided advantage over other methods of development.



That the canal scheme will permit the maximum degree of effective use to be made of the difference in level between Lake Erie and Lake Ontario, not only under present limiting conditions, but in the event of future diversion of water direct from Lake Erie.

And that, finally, the comparison of the estimates of capital cost for the various proposed schemes indicates that the canal scheme is substantially cheaper for all installed capacities up to the limit of the first stage of development.

Respectfully submitted,

(signed) H. G. ACRES.

Toronto, December 26th,1917. HYDRAULIC ENGINEER.

(Appendix IV)

ESTIMATE NO. 2.

Queenston-Chippawa Power Development

Summary of Estimated Quantities and Cost
200,000 Horse-power Installation

Canal Project — Revised November 27, 1917.

| | | | |
|---|---|---|---|
| Intake | | | $ 973,700.00 |
| Canal | - Welland River Division | $ 294,600.00 | |
| | Earth Division | 1,535,603.00 | |
| | Transition Earth to Rock | 47,168.00 | |
| | Rock Division No. 1 | 4,328,155.00 | |
| | Transition Rock to Whirlpool | 47,646.00 | |
| | Whirlpool Division | 715,002.00 | |
| | Transition Whirlpool to Rock | 53,120.00 | |
| | Rock Division No. 2 | 885,234.00 | |
| | Forebay | 399,874.00 | |
| | Right-of-way | 500,000.00 | 8,906,412.00 |
| Bridges | - Highway | 293,203.00 | |
| | Railway | 317,120.00 | 610,323.00 |
| Gate House | - | | 273,000.00 |
| Penstocks | - Exciter Penstock | 18,530.00 | |
| | No. 1 " | 63,158.00 | |
| | No. 2 " | 63,585.00 | |
| | No. 3 " | 63,488.00 | |
| | No. 4 " | 66,000.00 | 274,761.00 |
| Power House | - Substructure | 788,850.00 | |
| | Superstructure | 460,300.00 | 1,249,150.00 |
| Hydraulic Equipment | - | | 1,254,000.00 |
| Electrical Equipment | - | | 2,167,000.00 |
| Miscellaneous | - | | 160,000.00 |
| | | | $15,868,346.00 |
| Engineering and Contingencies | - 25% | | 3,967,087.00 |
| Interest During Construction | - 7½% | | 1,190,126.00 |
| | | | $21,025,559.00 |

Note: Earth Excavation estimated at 27 cents per cubic yard.
Rock Excavation estimated at 98 cents per cubic yard.

Note: Intake and Canal constructed for 300,000 Horse-power.

(Appendix V)

# ESTIMATE NO. 2.

## Queenston-Chippawa Power Development

## Summary of Estimated Quantities and Cost
## 150,000 Horse-power Installation

Canal Project — Revised November 27, 1917.

| | | | |
|---|---|---|---|
| Intake | | | $ 973,700.00 |
| Canal | - Welland River Division | $ 147,300.00 | |
| | Earth Division | 1,535,603.00 | |
| | Transition Earth to Rock | 47,168.00 | |
| | Rock Division No. 1 | 4,328,165.00 | |
| | Transition Rock to Whirlpool | 47,646.00 | |
| | Whirlpool Division | 715,002.00 | |
| | Transition Whirlpool to Rock | 53,120.00 | |
| | Rock Division No. 2 | 885,234.00 | |
| | Forebay | 399,874.00 | |
| | Right-of-way | 600,000.00 | 8,759,112.00 |
| Bridges | - Highway | 242,767.00 | |
| | Railway | 231,560.00 | 474,327.00 |
| Gate House | - | | 219,504.00 |
| Penstocks | - Exciter Penstock | 18,530.00 | |
| | No. 1 " | 63,158.00 | |
| | No. 2 " | 63,585.00 | |
| | No. 3 " | 63,488.00 | 208,761.00 |
| Power House | - Substructure | 698,350.00 | |
| | Superstructure | 345,300.00 | 1,043,650.00 |
| Hydraulic Equipment | - | | 885,000.00 |
| Electrical Equipment | - | | 1,625,000.00 |
| Miscellaneous | - | | 140,000.00 |
| | | | $14,329,054.00 |
| Engineering and Contingencies | - 25% | | 3,582,264.00 |
| Interest During Construction | - 7½% | | 1,074,679.00 |
| | | | $18,985,997.00 |

Note: Earth Excavation estimated at 27 cents per cubic yard.
Rock Excavation estimated at 98 cents per cubic yard.

Note: Canal and Intake constructed for 300,000 Horse-power.

ESTIMATE M. 2. (Appendix VI-a)

Queenston-Chippawa Power Development

Summary of Estimated Quantities and Cost
300,000 Horse-power Installation
Based on A.C.Douglass' Cost for Earth and
Rock plus 10%.

Canal Project November, 1917.

| | | | | |
|---|---|---|---|---|
| Intake | | | | $ 973,700.00 |
| Canal | - Welland River Division | | 533,384.00 | |
| | Earth Division | | 1,800,270.00 | |
| | Transition Earth to Rock | | 60,249.00 | |
| | Rock Division No. 1 | | 5,693,869.00 | |
| | Transition Rock to Whirlpool | | 89,163.00 | |
| | Whirlpool Division | | 836,964.00 | |
| | Transition Whirlpool to Rock | | 89,054.00 | |
| | Rock Division No. 2 | | 1,442,605.00 | |
| | Forebay | | 559,716.00 | |
| | Right-of-way | | 600,000.00 | 12,754,284.00 |
| Bridges | - Highway | | 293,203.00 | |
| | Railway | | 317,120.00 | 610,323.00 |
| Gate House | - | | | 378,004.00 |
| Penstocks | - Exciter Penstock | | 18,530.00 | |
| | No. 1 " | | 63,188.00 | |
| | No. 2 " | | 63,585.00 | |
| | No. 3 " | | 63,488.00 | |
| | No. 4 " | | 66,000.00 | |
| | No. 5 " | | 66,150.00 | |
| | No. 6 " | | 68,325.00 | 409,236.00 |
| Power House | - Substructure | | 969,850.00 | |
| | Superstructure | | 690,300.00 | 1,660,150.00 |
| Hydraulic Equipment | - | | | 1,768,000.00 |
| Electrical Equipment | - | | | 8,250,000.00 |
| Miscellaneous | - | | | 175,000.00 |
| | | | | $21,978,697.00 |
| Engineering and Contingencies | - 25% | | | 5,494,674.00 |
| Interest During Construction | - 7½% | | | 1,648,402.00 |
| | | | | $29,121,773.00 |

Note: Earth excavation estimated at 56⅔ cents per cubic yard.
Rock excavation estimated at $1.716 per cubic yard.

ESTIMATE NO. 2.

Queenston-Chippawa Power Development

Estimated Quantities and Cost
300,000 Horse-power Installation
Based on A.C.Douglass' Cost for
Earth and Rock plus 10%.

Canal Project November, 1917.

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| | | | | | |
|---|---|---|---|---|---|
| **INTAKE** | | | | | |
| Cofferdam | 1,980 | lin.ft. | at 100.00 | 198,000 | |
| Pumping | | | | 50,000 | |
| Excavation | 427,000 | cu.yds. | at .60 | 256,200 | |
| Concrete: | | | | | |
| Ship channel | 17,000 | | | | |
| Intake piers and ice curtain | 10,200 | | | | |
| Submerged retaining wall | 2,700 | | | | |
| Gathering wall | 17,000 | | | | |
| | 46,900 | cu.yds. | at 8.00 | 375,000 | |
| Reinforcing steel | 626,000 | lbs. | at .06 | 31,300 | |
| Steel plate | 57,600 | lbs. | at .10 | 5,760 | |
| Miscellaneous: | | | | | |
| Lighthouse for Chippawa Light | | | | 8,000 | |
| Sluice gate | | | | 10,000 | |
| Gates for ship channel | | | | 30,000 | |
| Mooring Jetty: | | | | | |
| Piling | 13,250 | lin.ft. | at .35 | 4,640 | |
| Lumber | 80,000 | f.b.m. | at 60.00 M. | 4,800 | $ 973,700 |
| **CANAL** | | | | | |
| Welland River Division | | | | | |
| Dredging | 2,504,000 | cu.yds. | at .20 | 500,800 | |
| Rip-rap | 17,600 | cu.yds. | at 1.50 | 26,400 | |
| Miscellaneous: | | | | | |
| Concrete core wall at North Channel, Hog Island | 700 | cu.yds. | at 8.00 | 5,600 | |
| Reinforcing steel | 11,700 | lbs. | at .05 | 584 | $ 533,384 |

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

(Appendix VI-c)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Earth Division, Station 0+00 to Station 79+00 Canal Chainage** | | | | | | |
| Dredging Sta.0+00 to 9+55 | 282,000 | cu.yds. | at | .20 | 56,400 | |
| Rip-rap at canal entrance, | 6,300 | cu.yds. | at | 1.50 | 9,450 | |
| Earth Excavation Sta.9+55 to 16+00 | 170,000 | cu.yds. | at | .385 | 65,400 | |
| Earth Excavation Sta.16+00 to 79+00 | 1,856,850 | cu.yds. | at | .385 | 699,387 | |
| Rock Excavation Sta.16+00 to 79+00 | 89,850 | cu.yds. | at | 1.716 | 154,183 | |
| Transition and Control Works: | | | | | | |
| Concrete | 21,000 | cu.yds. | at | 8.00 | 168,000 | |
| Rock fill on sides | 1,800 | cu.yds. | at | 1.50 | 2,700 | |
| Gates (two) | | | | | 30,000 | |
| Superstructure | 144,000 | cu.yds. | at | .12 | 17,300 | |
| Piling | 20,000 | feet | at | .35 | 7,000 | |
| Lining: | | | | | | |
| Concrete on bottom | 12,100 | cu.yds. | at | 6.50 | 78,650 | |
| Concrete on sides (reinforced) | 42,300 | cu.yds. | at | 10.00 | 423,300 | |
| Reinforcing steel | 1,870,000 | lbs. | at | .05 | 93,500 | |
| Rip-rap at water-line | 64,000 | cu.yds. | at | 1.50 | 96,000 | $ 1,800,270 |
| **Transition Earth to Rock, Station 79+00 to Station 81+00** | | | | | | |
| Earth excavation | 36,300 | cu.yds. | at | .385 | 13,976 | |
| Rock excavation | 12,100 | cu.yds. | at | 1.716 | 20,764 | |
| Concrete on bottom | 306 | cu.yds. | at | 6.50 | 1,989 | |
| Concrete on sides | 1,600 | cu.yds. | at | 12.00 | 19,200 | |
| Reinforcing steel | 33,000 | lbs. | at | .05 | 1,650 | |
| Rip-rap at waterline | 1,780 | cu.yds. | at | 1.50 | 2,670 | $ 60,249 |
| **Rock Division No. 1 (South of Whirlpool), Sta.81+00 to Sta.231+00** | | | | | | |
| Earth excavation | 6,107,600 | cu.yds. | at | .385 | 2,351,426 | |
| Rock excavation | 2,258,600 | cu.yds. | at | 1.716 | 3,875,758 | |
| Concrete on bottom | 22,200 | cu.yds. | at | 6.50 | 144,300 | |
| Concrete on earth slopes | 16,700 | cu.yds. | at | 10.00 | 167,000 | |
| Reinforcing steel | 819,700 | lbs. | at | .05 | 40,985 | |
| Rip-rap at waterline | 75,600 | cu.yds. | at | 1.50 | 113,400 | $ 6,692,869 |

| | | | | | |
|---|---|---|---|---|---|
| **Transition from Rock Division to Whirlpool Division, Sta.331+00 to Sta.333+00** | | | | | |
| Earth excavation ..... | 48,500 cu.yds. | at | .385 | 18,696 | |
| Rock excavation ..... | 8,100 cu.yds. | at | 1.716 | 13,900 | |
| Concrete on bottom ..... | 161 cu.yds. | at | 6.50 | 1,047 | |
| Concrete on sides, (reinforced)..... | 1,775 cu.yds. | at | 12.00 | 21,300 | |
| Reinforcing steel ..... | 33,000 lbs. | at | .05 | 1,650 | |
| Rip-rap at waterline ... | 1,780 cu.yds. | at | 1.50 | 2,570 | $ 59,163 |
| **Whirlpool Division, Station 333+00 to Station 364+00** | | | | | |
| Fill (600 ft.): | | | | | |
| Rock fill ..... | 204,800 cu.yds. | ..... | | No charge | |
| Earth fill ..... | ..... | | | No charge | |
| Concrete on bottom | 330 cu.yds. | at | 6.50 | 2,145 | |
| Concrete on sides, (reinforced) .... | 6,500 cu.yds. | at | 12.00 | 78,000 | |
| Reinforcing steel . | 214,000 lbs. | at | .05 | 10,700 | |
| Cut: | | | | | |
| Earth excavation .. | 784,700 cu.yds. | at | .385 | 302,109 | |
| Rock excavation .. | 43,100 cu.yds. | at | 1.716 | 73,960 | |
| Concrete on bottom | 1,390 cu.yds. | at | 6.50 | 9,380 | |
| Concrete on sides | 27,180 cu.yds. | at | 10.00 | 271,800 | |
| Reinforcing steel | 1,112,000 lbs. | at | .05 | 55,600 | |
| Rip-rap at waterline ..... | 22,200 cu.yds. | at | 1.50 | 33,300 | $ 836,964 |
| **Transition from Whirlpool Division to Rock Division No. 2. Station 364+00 to Station 366+00** | | | | | |
| Earth excavation ..... | 58,000 cu.yds. | at | .385 | 22,330 | |
| Rock excavation ..... | 12,600 cu.yds. | at | 1.716 | 21,622 | |
| Concrete on bottom .... | 161 cu.yds. | at | 6.50 | 1,047 | |
| Concrete on sides, (reinforced) ..... | 1,520 cu.yds. | at | 12.00 | 18,240 | |
| Reinforcing steel ..... | 63,100 lbs. | at | .05 | 3,155 | |
| Rip-rap at waterline .. | 1,780 cu.yds. | at | 1.50 | 2,570 | $ 69,064 |
| **Rock Division No. 2 (North of Whirlpool), Sta.366+00 to Sta.453+00** | | | | | |
| Earth excavation ..... | 174,700 cu.yds. | at | .385 | 67,260 | |
| Rock excavation ..... | 730,000 cu.yds. | at | 1.716 | 1,252,680 | |
| Concrete on bottom .... | 7,750 cu.yds. | at | 6.50 | 50,375 | |
| Reinforcing steel ..... | 61,000 lbs. | at | .05 | 3,050 | |
| Rip-rap at waterline .. | 6,700 cu.yds. | at | 1.50 | 10,050 | |
| Concrete on sides, (reinforced)..... | 1,460 cu.yds. | at | 10.00 | 14,600 | |
| Embankments: | | | | | |
| Concrete core wall | 3,920 cu.yds. | at | 8.00 | 31,360 | |
| Rip-rap ..... | 6,700 cu.yds. | at | 1.50 | 10,050 | |
| Reinforcing steel . | 63,600 lbs. | at | .05 | 3,180 | $ 1,442,605 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Forebay, Station 453+00 to Station 462+17** | | | | | | |
| Earth excavation ..... | 22,700 | cu.yds. | at | .385 | 8,739 | |
| Rock excavation ..... | 349,600 | cu.yds. | at | 1.716 | 599,742 | |
| Concrete on bottom ..... | 5,950 | cu.yds. | at | 6.50 | 38,675 | |
| Concrete on sides (plain) | 415 | cu.yds. | at | 8.00 | 3,320 | |
| Embankments: | | | | | | |
| Concrete core wall . | 555 | cu.yds. | at | 8.00 | 4,440 | |
| Rip-rap ..... | 2,800 | cu.yds. | at | 1.50 | 4,200 | |
| Reinforcing steel .. | 12,000 | lbs. | at | .05 | 600 | $ 659,716 |
| **HIGHWAY BRIDGES** | | | | | | |
| **Welland River Division** | | | | | | |
| Chippawa Highway Bridge: | | | | | | |
| Piling, temp. bridge | 3,300 | feet | at | .40 | 1,320 | |
| Deck ..... | 28,000 | f.b.m. | at | 60.00 | 1,680 | |
| Timber in cofferdam | 150,000 | f.b.m. | at | 60.00 | 9,000 | |
| Puddle ..... | 1,800 | cu.yds. | at | 1.00 | 1,800 | |
| Excavation ..... | 3,000 | cu.yds. | at | 2.00 | 6,000 | |
| Sheet piling ..... | 10,000 | f.b.m. | at | 60.00 | 600 | |
| Concrete, including rest piers | 3,300 | cu.yds. | at | 10.00 | 33,000 | |
| Floor system ..... | 180 | cu.yds. | at | 10.00 | 2,160 | |
| Pony span ..... | 80,000 | lbs. | at | .10 | 8,000 | |
| Swing span ..... | 200,000 | lbs. | at | .10 | 20,000 | |
| Pier guards ..... | | | | | 500 | |
| | | | | | 84,060 | |
| Less portion of cost assumed by Municipality - 40% | | | | | 33,624 | $ 50,436 |
| **Welland Division** | | | | | | |
| At Station 22+53: | | | | | | |
| Earth excavation .. | 400 | cu. yds. | at | .40 | 160 | |
| Concrete ..... | 800 | cu. yds. | at | 10.00 | 800 | |
| Structural steel .. | 152,100 | lbs. | at | .07 | 10,647 | $ 11,607 |
| Patrol Bridge at Sta.69+00 for T.P.Co. ..... | | | | | | $ 3,000 |
| **Rock Division** | | | | | | |
| At Station 95+50: | | | | | | |
| Rock excavation ... | 625 | cu.yds. | at | 2.00 | 1,250 | |
| Concrete ..... | 1,740 | cu.yds. | at | 10.00 | 17,400 | |
| Reinforcing steel . | 24,300 | lbs. | at | .05 | 1,215 | |
| Fill ..... | 11,550 | cu.yds. | at | .10 | 1,165 | $ 21,030 |
| At Station 167+00, Lundys Lane: | | | | | | |
| Rock excavation ... | 670 | cu.yds. | at | 2.00 | 1,340 | |
| Concrete excavation | 3,400 | cu.yds. | at | 10.00 | 34,000 | |
| Reinforcing steel . | 48,600 | lbs. | at | .05 | 2,430 | |
| Fill ..... | 72,800 | cu.yds. | at | .10 | 7,280 | $ 45,050 |

Rock Division (continued)

At Station 197+00, Winery Road:

| | | | | | |
|---|---|---|---|---|---|
| Rock excavation .... | 340 cu.yds. | at | 2.00 | 680 | |
| Concrete ..... | 1,500 cu.yds. | at | 10.00 | 15,000 | |
| Reinforcing steel .. | 24,300 lbs. | at | .05 | 1,215 | |
| Fill ..... | 8,450 cu.yds. | at | .10 | 845 | $ 17,740 |

At Station 239+00, Victoria Street:

| | | | | | |
|---|---|---|---|---|---|
| Rock excavation .... | 670 cu.yds. | at | 2.00 | 1,340 | |
| Concrete ..... | 3,400 cu.yds. | at | 10.00 | 34,000 | |
| Reinforcing steel .. | 48,600 lbs. | at | .05 | 2,430 | |
| Fill ..... | 68,400 cu.yds. | at | .10 | 6,840 | $ 44,610 |

At Station 256+00, Portage Road:

| | | | | | |
|---|---|---|---|---|---|
| Rock excavation .... | 670 cu.yds. | at | 2.00 | 1,340 | |
| Concrete ..... | 3,400 cu.yds. | at | 10.00 | 34,000 | |
| Reinforcing steel .. | 48,600 lbs. | at | .05 | 2,430 | |
| Fill ..... | 68,400 cu.yds. | at | .10 | 6,840 | $ 44,610 |

At Station 297+00, Thorold Stone Road:

| | | | | | |
|---|---|---|---|---|---|
| Rock excavation .... | 580 cu.yds. | at | 2.00 | 1,160 | |
| Concrete ..... | 2,100 cu.yds. | at | 10.00 | 21,000 | |
| Reinforcing steel .. | 56,400 lbs. | at | .05 | 2,820 | |
| Fill ..... | 21,500 cu.yds. | at | .10 | 2,150 | $ 27,130 |



Whirlpool Division

At Station 351+00, Victoria Avenue:

| | | | | | |
|---|---|---|---|---|---|
| Earth excavation ... | 430 cu.yds. | at | .40 | 180 | |
| Concrete ..... | 1,000 cu.yds. | at | 10.00 | 10,000 | |
| Structural steel ... | 244,000 lbs. | at | .07 | 17,080 | |
| Piling ..... | 2,000 lin.ft. | at | .35 | 700 | |
| Fill ..... | 300 cu.yds. | at | .10 | 30 | $ 27,990 |

RAILROAD BRIDGES:

Welland River Division

N.C.R. Bridge, Chippawa:

| | | | | | |
|---|---|---|---|---|---|
| Piling (Diversion) | 6,000 lin.ft. | at | .40 | 2,800 | |
| Deck ..... | 32,000 f.b.m. | at | 60.00 | 1,920 | |
| Moving span twice, and track laying | 1,100 lin.ft. | at | .40 | 440 | |
| Sheet piling ..... | 10,000 f.b.m. | at | 60.00 | 600 | |
| Puddle ..... | 1,800 cu.yds. | at | 1.00 | 1,800 | |
| Timber on cofferdams | 150,000 f.b.m. | at | 60.00 | 9,000 | |
| Excavation in cofferdams ..... | 3,000 cu.yds. | at | 12.00 | 6,000 | |
| Concrete piers and abutments, including rest piers ... | 4,600 cu.yds. | at | 10.00 | 46,000 | |
| Pier guards ..... | | | | 500 | |
| Two R.P.G. spans ... | 240,000 lbs. | at | .10 | 24,000 | |
| | | | | 94,560 | |
| Portion of cost to be assumed by N.C.R. | | | | 9,000 | $ 85,560 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Earth Division** | | | | | | |
| M.C.R. Montrose Station: | | | | | | |
| Sheet Piling ..... | 30,000 | f.b.m. | at 60.00 | 11,800 | | |
| Piling ..... | 2,400 | lin.ft. | at .40 | 950 | | |
| Excavation ..... | 1,600 | cu.yds. | at 1.00 | 1,600 | | |
| Underpinning ..... | | | | 350 | | |
| Concrete ..... | 1,385 | cu.yds. | at 10.00 | 13,850 | | |
| Deck ..... | 30,000 | f.b.m. | at 60.00 | 1,800 | | |
| Two 85' D.P.G.Spans | 240,000 | lbs. | at .10 | 24,000 | $ | 44,350 |
| **Rock Division** | | | | | | |
| N.St.C. & T.Ry.Arch, Station 273+85: | | | | | | |
| Concrete ..... | 3,500 | cu.yds. | at 10.00 | 35,000 | | |
| Steel ..... | 258,000 | lbs. | at .04 | 10,320 | $ | 45,320 |
| G.T.R. (Wabash) Arch, Station 310+47: | | | | | | |
| Concrete ..... | 3,400 | cu.yds. | at 10.00 | 34,000 | | |
| Steel ..... | 244,000 | lbs. | at .04 | 9,760 | $ | 43,760 |
| M.C.R. & G.T.R. Arch, Station 324+08: | | | | | | |
| Concrete ..... | 8,500 | cu.yds. | at 10.00 | 85,000 | | |
| Steel ..... | 328,000 | lbs. | at .04 | 13,120 | $ | 98,120 |
| Right-of-way ..... | | | | | $ | 600,000 |
| **GATE HOUSE** | | | | | | |
| Earth excavation ..... | None | | | | | |
| Rock excavation ..... | 23,500 | cu.yds. | at 1.716 | 40,326 | | |
| Concrete (reinforced) ..... | 3,000 | cu.yds. | at 12.00 | 36,000 | | |
| Concrete (plain) ..... | 10,000 | cu.yds. | at 8.00 | 80,000 | | |
| Reinforcing steel ..... | 320,000 | lbs. | at .05 | 16,000 | | |
| Structural steel and racks .. | 402,000 | lbs. | at .07 | 28,140 | | |
| Ice Chute: | | | | | | |
| Concrete ..... | 965 | cu.yds. | at 6.50 | 6,273 | | |
| Steel ..... | 164,000 | lbs. | at .05 | 8,200 | | |
| Gates ..... | 6 | at $10,000 | each | 60,000 | | |
| Superstructure ..... | 687,100 | cu.ft. | at .15 | 103,066 | $ | 378,004 |
| **PENSTOCKS** | | | | | | |
| Exciter Penstock | | | | | | |
| Tunnel excavation ..... | 180 | cu.yds. | at 6.00 | 1,080 | | |
| Rock excavation ..... | 600 | cu.yds. | at 2.25 | 1,350 | | |
| Steel work ..... | 165,000 | lbs. | at .07 | 11,550 | | |
| Concrete around penstock | 700 | cu.yds. | at 6.50 | 4,550 | $ | 18,530 |
| Penstock No. 1 | | | | | | |
| Tunnel excavation ..... | 520 | cu.yds. | at 6.00 | 3,120 | | |
| Rock excavation ..... | 1,150 | cu.yds. | at 2.25 | 2,588 | | |
| Steel work ..... | 700,000 | lbs. | at .07 | 49,000 | | |
| Concrete around penstock | 1,300 | cu.yds. | at 6.50 | 8,450 | $ | 63,158 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Penstock No. 2** | | | | | | |
| Tunnel excavation ..... | 460 | cu.yds. | at | 6.00 | 2,760 | |
| Rock excavation ..... | 1,500 | cu.yds. | at | 2.25 | 3,375 | |
| Steel work ..... | 700,000 | lbs. | at | .07 | 49,000 | |
| Concrete around penstock | 1,300 | cu.yds. | at | 6.50 | 8,450 | $ 63,585 |
| **Penstock No. 3** | | | | | | |
| Tunnel excavation ..... | 500 | cu.yds. | at | 6.00 | 3,000 | |
| Rock excavation ..... | 1,350 | cu.yds. | at | 2.25 | 3,038 | |
| Steel work ..... | 700,000 | lbs. | at | .07 | 49,000 | |
| Concrete around penstock | 1,300 | cu.yds. | at | 6.50 | 8,450 | $ 63,488 |
| **Penstock No. 4** | | | | | | |
| Tunnel excavation ..... | 600 | cu.yds. | at | 6.00 | 3,600 | |
| Rock excavation ..... | 2,200 | cu.yds. | at | 2.25 | 4,950 | |
| Steel work ..... | 700,000 | lbs. | at | .07 | 49,000 | |
| Concrete around penstock | 1,300 | cu.yds. | at | 6.50 | 8,450 | $ 66,000 |
| **Penstock No. 5** | | | | | | |
| Tunnel excavation ..... | 700 | cu.yds. | at | 6.00 | 4,200 | |
| Rock excavation ..... | 2,000 | cu.yds. | at | 2.25 | 4,500 | |
| Steel work ..... | 700,000 | lbs. | at | .07 | 49,000 | |
| Concrete around penstock | 1,300 | cu.yds. | at | 6.50 | 8,450 | $ 66,150 |
| **Penstock No. 6** | | | | | | |
| Tunnel excavation ..... | 800 | cu.yds. | at | 6.00 | 4,800 | |
| Rock excavation ..... | 2,700 | cu.yds. | at | 2.25 | 6,075 | |
| Steel work ..... | 700,000 | lbs. | at | .07 | 49,000 | |
| Concrete around penstock | 1,300 | cu.yds. | at | 6.50 | 8,450 | $ 68,325 |
| **POWER HOUSE** | | | | | | |
| **Substructure** | | | | | | |
| Unwatering ..... | | | | | 50,000 | |
| Talus excavation ..... | 219,500 | cu.yds. | at | 1.00 | 219,500 | |
| Rock excavation ..... | 104,900 | cu.yds. | at | 1.50 | 157,350 | |
| Concrete in substructure | 66,000 | cu.yds. | at | 8.00 | 528,000 | |
| Reinforcing steel ..... | 300,000 | lbs. | at | .05 | 15,000 | $ 969,850 |
| **HYDRAULIC EQUIPMENT** | | | | | | |
| Main Turbines and Governors | 6 | at | $ 270,000.00 | | 1,620,000 | |
| Exciter Turbine and Governors | 2 | at | $ 24,000.00 | | 48,000 | |
| Auxiliary equipment ..... | | | | | 100,000 | $ 1,768,000 |
| **Superstructure** ..... | 4,602,000 | cu.ft. | at | .15 | | $ 690,300 |
| **ELECTRICAL EQUIPMENT** ..... | 6 units ..... | | | | | $ 3,250,000 |
| **MISCELLANEOUS** | | | | | | |
| Service tunnel ..... | 600 feet | | at | 125.00 | 75,000 | |
| Sundries ..... | | | | | 100,000 | $ 175,000 |

ESTIMATE NO. 2.

Queenston-Chippawa Power Development

Summary of Estimated Quantities and Cost.
Classified According to Material

| | | | | | |
|---|---|---|---|---|---|
| **Dredging** | | | | | |
| Welland River Division | 2,504,000 | | | | |
| Earth Division ..... | 282,000 | 2,786,000 cu.yds. at | .20 | $ | 557,200 |
| **Earth Excavation** | | | | | |
| Intake ..... | | 427,000 cu.yds. at | .60 | $ | 256,200 |
| Earth Division, Sta. 0+00 - 79+00 ..... | 1,726,850 | | | | |
| Transition, Sta. 79+00 - 81+00 ..... | 36,300 | | | | |
| Rock Division No. 1, Sta.81+00 - 331+00 .. | 6,107,600 | | | | |
| Transition, Sta. 331+00 - 333+00 ..... | 48,300 | | | | |
| Whirlpool Division, Sta.333+00 - 364+00 . | 754,700 | | | | |
| Transition, Sta. 364+00 - 366+00 ..... | 58,000 | | | | |
| Rock Division No. 2, Sta.366+00 - 453+00 . | 174,700 | | | | |
| Forebay, Sta. 453+00 - 462+17 ..... | 22,700 | 6,959,150 cu.yds. at | .385 | $ | 3,449,273 |
| Highway bridges at Sta.22+53 ..... | 400 | | | | |
| Highway bridges at Sta.351+00 ..... | 450 | 850 cu.yds. at | .40 | $ | 340 |
| **Rock Excavation** | | | | | |
| Earth Division, Sta. 0+00 - 79+00 ..... | 89,850 | | | | |
| Transition, Sta.79+00 - 81+00 ..... | 12,100 | | | | |
| Rock Division No. 1, Sta.79+00 - 331+00 .. | 2,258,300 | | | | |
| Transition, Sta. 331+00 - 333+00 ..... | 8,100 | | | | |
| Whirlpool Division, Sta. 333+00 - 364+00 ..... | 43,100 | | | | |
| Transition, Sta. 364+00 - 366+00 ..... | 12,600 | | | | |
| Rock Division No. 2, Sta.366+00 - 453+00 . | 730,000 | | | | |
| Forebay, Sta.453+00 - 462+35 ..... | 349,500 | | | | |
| Gate House ..... | 23,500 | 3,527,350 cu.yds. at | 1.716 | $ | 6,052,933 |

| | | | | |
|---|---|---|---|---|
| **Rock Excavation (continued)** | | | | |
| Highway bridges at: | | | | |
| Sta. 95+50 ..... | 625 | | | |
| Sta.167+00 ..... | 670 | | | |
| Sta.197+00 ..... | 340 | | | |
| Sta.239+00 ..... | 670 | | | |
| Sta.256+00 ..... | 670 | | | |
| Sta.297+30 ..... | 580 | 3,555 cu.yds. at | 2.00 | $ 7,110 |
| Penstocks: | | | | |
| Exciter ..... | 600 | | | |
| No. 1 ..... | 1,150 | | | |
| No. 2 ..... | 1,500 | | | |
| No. 3 ..... | 1,350 | | | |
| No. 4 ..... | 2,200 | | | |
| No. 5 ..... | 2,000 | | | |
| No. 6 ..... | 2,700 | 11,500 cu.yds. at | 2.25 | $ 25,875 |
| Power House: | | | | |
| Talus ..... | | 219,500 cu.yds. at | 1.00 | $ 219,500 |
| Rock ..... | | 104,900 cu.yds. at | 1.50 | $ 157,350 |
| **Tunnel Excavation (Rock)** | | | | |
| Penstocks: | | | | |
| Exciter ..... | 180 | | | |
| No. 1 ..... | 520 | | | |
| No. 2 ..... | 460 | | | |
| No. 3 ..... | 500 | | | |
| No. 4 ..... | 600 | | | |
| No. 5 ..... | 700 | | | |
| No. 6 ..... | 800 | 3,760 cu.yds. at | 6.00 | $ 22,560 |
| **Rip-rap and Rock Fill** | | | | |
| Welland Division ..... | 17,600 | | | |
| Earth Division Entrance | 6,300 | | | |
| Transition and Control | 1,800 | | | |
| Canal (at waterline) .. | 64,000 | | | |
| Transition Earth to Rock | 1,780 | | | |
| Rock Division No. 1 ... | 75,600 | | | |
| Transition Rock to Whirlpool ..... | 1,780 | | | |
| Whirlpool Division .... | 22,200 | | | |
| Transition Whirlpool to Rock ..... | 1,780 | | | |
| Rock Division No. 2 ... | 13,400 | | | |
| Forebay ..... | 2,800 | 209,040 cu.yds. at | 1.50 | $ 313,560 |
| Rock fill at Whirlpool Gorge ..... | | 204,800 cu.yds. at | No charge | |

| | | | | |
|---|---|---|---|---|
| **Concrete (Plain)** | | | | |
| Earth Division, Sta. 0+00 - 79+00 | 12,100 | | | |
| Transition, Sta.79+00 - 81+00 | 306 | | | |
| Rock Division No. 1, Sta.81+00 - 331+00 | 22,200 | | | |
| Transition, Sta.331+00 - 333+00 | 161 | | | |
| Whirlpool Division, Sta. 333+00 - 364+00 | 1,720 | | | |
| Transition, Sta.364+00 - 366+00 | 161 | | | |
| Rock Division No. 2, Sta.366+00 - 453+00 | 7,750 | | | |
| Forebay, Sta.453+00 - 452+35 | 5,950 | | | |
| Ice Chute | 965 | | | |
| Penstocks: | | | | |
| Exciter | 700 | | | |
| No. 1 | 1,300 | | | |
| No. 2 | 1,300 | | | |
| No. 3 | 1,300 | | | |
| No. 4 | 1,300 | | | |
| No. 5 | 1,300 | | | |
| No. 6 | 1,300 | 59,813 cu.yds. at | 6.50 | $ 388,785 |
| **Concrete (Reinforced and Plain)** | | | | |
| Intake | 46,900 | | | |
| Welland River Division | 700 | | | |
| Earth Division, Sta. 0+00 - 79+00 | 21,000 | | | |
| Rock Division No. 2, Sta.366+00 - 453+00 | 3,920 | | | |
| Forebay, Sta.453+00 - 452+35 | 970 | | | |
| Gate House | 10,000 | | | |
| Power House | 66,000 | 149,490 cu.yds. at | 8.00 | $ 1,195,920 |
| **Concrete (Reinforced)** | | | | |
| Earth Division, Sta. 0+00 - 79+00 | 42,250 | | | |
| Rock Division No. 1, Sta.81+00 - 331+00 | 16,700 | | | |
| Whirlpool Division, Sta.333+00 - 364+00 | 27,160 | | | |
| Rock Division No. 2, Sta.366+00 - 453+00 | 1,460 | 87,570 cu.yds. at | 10.00 | $ 875,700 |

| | | | |
|---|---|---|---|
| **Concrete (Reinforced) (continued)** | | | |
| Highway bridges: | | | |
| Chippawa Highway | 3,480 | | |
| Sta. 22+53 | 800 | | |
| Sta. 95+50 | 1,740 | | |
| Sta.167+00 | 3,400 | | |
| Sta.197+00 | 1,500 | | |
| Sta.239+00 | 3,400 | | |
| Sta.256+00 | 3,400 | | |
| Sta.297+30 | 2,100 | | |
| Sta.351+00 | 1,000 | | |
| Railway bridges: | | | |
| M.C.R.Bridge, Chippawa | 4,600 | | |
| M.C.R. | 1,385 | | |
| N.St.C. & T.Ry.Arch | 3,500 | | |
| G.T.R. (Wabash) Arch | 3,400 | | |
| M.C.R. | 8,500 | 42,205 cu.yds. at 10.00 | $ 422,050 |
| Transition, Sta. 79+00 - 81+00 | 1,600 | | |
| Transition, Sta. 331+00 - 333+00 | 1,775 | | |
| Whirlpool Division, Sta.333+00-364+00 | 6,500 | | |
| Transition, Sta. 364+00 - 366+00 | 1,520 | | |
| Gate House | 3,000 | 14,395 cu.yds. at 12.00 | $ 172,740 |
| **Reinforcing Steel** | | | |
| Intake | 626,000 | | |
| Welland River Division | 11,700 | | |
| North Division, Sta. 0+00 - 79+00 | 1,870,000 | | |
| Transition, Sta.79+00 - 81+00 | 33,000 | | |
| Rock Division No. 1, Sta.81+00 - 331+00 | 819,700 | | |
| Transition, Sta.331+00 - 333+00 | 33,000 | | |
| Whirlpool Division, Sta. 333+00 - 364+00 | 1,326,000 | | |
| Transition, Sta.364+00 - 366+00 | 63,100 | | |
| Rock Division No. 2, Sta.366+00 - 453+00 | 124,600 | | |
| Forebay, Sta.453+00 - 462+35 | 12,000 | | |
| Gate House | 320,000 | | |
| Power House (Substructure) | 300,000 | 5,539,100 lbs. at | .05 $ 276,955 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Reinforcing Steel (continued)** | | | | | | |
| Highway bridges: | | | | | | |
| Sta. 98+50 | 24,300 | | | | | |
| Lundys Lane | 48,600 | | | | | |
| Winery Road | 24,300 | | | | | |
| Victoria Street | 48,600 | | | | | |
| Portage Road | 48,600 | | | | | |
| Thorold Road | 56,400 | 250,800 lbs. | at | .05 | $ | 12,540 |
| Railway bridges: | | | | | | |
| N.St.C. & T.Ry.Arch | 258,000 | | | | | |
| G.T.R. (Wabash) Arch | 244,000 | | | | | |
| M.C.R. & G.T.R. | 328,000 | 830,000 lbs. | at | .04 | $ | 33,200 |
| **Structural Steel and Plate** | | | | | | |
| Intake | | 57,600 lbs. | at | .10 | $ | 5,760 |
| Gate House | 402,000 | | | | | |
| Penstocks: | | | | | | |
| Exciter | 165,000 | | | | | |
| No. 1 | 700,000 | | | | | |
| No. 2 | 700,000 | | | | | |
| No. 3 | 700,000 | | | | | |
| No. 4 | 700,000 | | | | | |
| No. 5 | 700,000 | | | | | |
| No. 6 | 700,000 | 4,767,000 lbs. | at | .07 | $ | 333,690 |
| Highway bridges: | | | | | | |
| Chippewa Highway Bridge | | 280,000 lbs. | at | .10 | $ | 28,000 |
| Sta. 22+53 | 152,100 | | | | | |
| Sta.351+00 Victoria Avenue | 244,000 | 396,100 lbs. | at | .07 | $ | 27,727 |
| Railway bridges: | | | | | | |
| M.C.R. Bridge, Chippewa | 240,000 | | | | | |
| M.C.R. Bridge, Montrose | 240,000 | 480,000 lbs. | at | .10 | $ | 48,000 |

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

(Appendix VII)

ESTIMATE NO. 2.

Queenston-Chippawa Power Development

Summary of Cost
300,000 Horse-power Installation

Tunnel Project November, 1917.

| | | |
|---|---|---|
| Intake | | $ 972,500.00 |
| Tunnel | | 14,131,000.00 |
| Right-of-way | | 150,000.00 |
| Distributors | | 190,640.00 |
| Penstocks (Exciter and 6 Main Penstocks) | | 359,460.00 |
| Surge Tanks | | 313,864.00 |
| Power House - Substructure | $969,850.00 | |
| Superstructure | 690,300.00 | 1,660,150.00 |
| Hydraulic Equipment | | 2,248,000.00 |
| Electrical Equipment | | 3,250,000.00 |
| Miscellaneous | | 175,000.00 |
| | | $23,400,614.00 |
| Engineering and Contingencies - 25% | | 5,850,154.00 |
| Interest During Construction - 7½% | | 1,755,046.00 |
| | | $31,005,814.00 |



Note: If the head canal as proposed for combined Tunnel and Canal Scheme were constructed as headworks for the Tunnel Scheme in place of the headworks proposed by Mr. Johnson, the above estimate would be reduced to $29,736,197.00.

WALTER J. FRANCIS & COMPANY.

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(Appendix VIII)

ESTIMATE NO. 2.

Queenston-Chippawa Power Development

Summary of Cost
200,000 Horse-power Installation

Tunnel Project — November, 1917.

| | | |
|---|---|---|
| Intake | | $ 972,500.00 |
| Tunnel | | 14,131,000.00 |
| Right-of-way | | 100,000.00 |
| Distributors | | 190,640.00 |
| Penstocks (Exciter and 4 Main Penstocks) | | 256,774.00 |
| Surge Tank | | 313,864.00 |
| Power House - Substructure | $788,850.00 | |
| Superstructure | 460,300.00 | 1,249,150.00 |
| Hydraulic Equipment | | 1,574,000.00 |
| Electrical Equipment | | 2,167,000.00 |
| Miscellaneous | | 160,000.00 |
| | | $21,114,928.00 |
| Engineering and Contingencies - 25% | | 5,278,732.00 |
| Interest During Construction - 7½% | | 1,583,620.00 |
| | | $27,977,280.00 |



Note: If the head canal as proposed for combined Tunnel and Canal Scheme were constructed as headworks for the Tunnel Scheme in place of the headworks proposed by Mr. Johnson, the above estimate would be reduced to $26,707,633.00.

Intake, Tunnel, Distributor and Surge Tank all for 300,000 Horse-power.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross. (Appendix IX)

ESTIMATE NO. 2.

Queenston-Chippawa Power Development

Summary of Cost
150,000 Horse-power Installation

Tunnel Project November, 1917.

| | | |
|---|---|---|
| Intake | | $ 972,500.00 |
| Tunnel | | 14,131,000.00 |
| Right-of-way | | 100,000.00 |
| Distributor | | 190,640.00 |
| Penstocks | | 205,431.00 |
| Surge Tank | | 313,864.00 |
| Power House - Substructure | $698,350.00 | |
| Superstructure | 345,300.00 | 1,043,650.00 |
| Hydraulic Equipment | | 1,125,000.00 |
| Electrical Equipment | | 1,625,000.00 |
| Miscellaneous | | 140,000.00 |
| | | $19,947,085.00 |
| Engineering and Contingencies - 25% | | 4,961,771.00 |
| Interest During Construction - 7½% | | 1,488,531.00 |
| | | $26,297,387.00 |



Note: If the head canal as proposed for combined Tunnel and Canal Scheme were constructed as headworks for the Tunnel Scheme in place of the headworks proposed by Mr. Johnson, the above estimate would be reduced to $25,027,771.00.

Intake, Tunnel, Distributor and Surge Tank all for 300,000 Horse-power.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross. EXHIBIT NO. 2. (Appendix Y-a)

Queenston-Chippawa Power Development

Summary of Cost
300,000 Horse-power Installation

November, 1917.

Combined Tunnel and Canal Project

| | | | |
|---|---|---|---|
| Intake | | | $ 780,460.00 |
| Entrance Canal and Control Works | | | 802,996.00 |
| Tunnel | - 37'-0", 13,300 lin.ft. (at $347.00) (Including Drain) | | 4,735,100.00 |
| Canal | - Rock Division No. 1 | 2,333,875.00 | |
| | Transition Rock to Whirlpool | 52,482.00 | |
| | Whirlpool Division | 782,950.00 | |
| | Transition Whirlpool to Rock | 59,272.00 | |
| | Lock Division No. 2 | 986,810.00 | |
| | Forebay | 443,630.00 | 4,659,019.00 |
| Right-of-way | | | 300,000.00 |
| Highway Bridges | - Chippawa Highway | 84,060.00 | |
| | Station Morrison Street | 44,610.00 | |
| | Station 297+30 Thorold St. | 27,130.00 | |
| | Station 351+00 Victoria Ave. | 27,990.00 | 183,790.00 |
| Railway Bridges | - N.St.C. & T.Arch | 45,320.00 | |
| | G.T.R. (Wabash) Arch | 43,760.00 | |
| | M.C.R. & G.T.R. | 98,120.00 | 187,200.00 |
| Gate House | | | 363,528.00 |
| Penstocks | - Exciter Penstock | 18,530.00 | |
| | No. 1 " | 63,158.00 | |
| | No. 2 " | 63,595.00 | |
| | No. 3 " | 63,488.00 | |
| | No. 4 " | 66,000.00 | |
| | No. 5 " | 66,150.00 | |
| | No. 6 " | 68,325.00 | 409,236.00 |
| Power House | - Substructure | 969,850.00 | |
| | Superstructure | 690,300.00 | 1,660,150.00 |
| Hydraulic Equipment | | | 1,968,000.00 |
| Electrical Equipment | | | 3,250,000.00 |
| Miscellaneous | | | 175,000.00 |
| | | | $19,274,479.00 |
| Engineering and Contingencies - 25% | | | 4,818,620.00 |
| Interest During Construction - 7½% | | | 1,445,586.00 |
| | | | $25,538,685.00 |

Note: If timbering be required in only half the length of tunnel work, the grand total would be reduced to $24,913,085.00.

This estimate is based on the following unit costs:

Earth excavation at 35 cents per cubic yard.

Rock excavation at $1.10 per cubic yard.

Tunnel at $347.00 per lineal foot for section with timbering.

Tunnel at $276.00 per lineal foot for section without timbering.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

PLATE NO. 2. (Appendix XI-a)

## Queenston-Chippawa Power Development

### Summary of Cost
### 200,000 Horse-power Installation

November, 1917.

Combined Tunnel and Canal Project

| | | | |
|---|---|---|---|
| Intake | | | $ 780,460.00 |
| Entrance Canal and Control Works | | | 802,995.00 |
| Tunnel | - 37'-0", 13,300 lin.ft. (at $347.00) Including Drain) | | 4,735,100.00 |
| Canal | - Rock Division No. 1 | 2,333,875.00 | |
| | Transition Rock to Whirlpool | 52,482.00 | |
| | Whirlpool Division | 782,950.00 | |
| | Transition Whirlpool to Rock | 59,272.00 | |
| | Rock Division No. 2 | 986,810.00 | |
| | Forebay | 443,630.00 | 4,659,019.00 |
| Right-of-way | | | 300,000.00 |
| Highway Bridges | - Chippawa Highway | 84,060.00 | |
| | Station Morrison Street | 44,610.00 | |
| | Station 297+30 Thorold St. | 27,130.00 | |
| | Station 351+00 Victoria Ave. | 27,990.00 | 183,790.00 |
| Railway Bridges | - N.St.C. & T. Arch | 45,320.00 | |
| | G.T.R. (Wabash) Arch | 43,760.00 | |
| | N.C.R. & G.T.R. | 98,120.00 | 187,200.00 |
| Gate House | | | 273,000.00 |
| Penstocks | - Exciter Penstock | 18,530.00 | |
| | No. 1 " | 63,158.00 | |
| | No. 2 " | 63,585.00 | |
| | No. 3 " | 63,488.00 | |
| | No. 4 " | 66,000.00 | 274,761.00 |
| Power House | - Substructure | 788,850.00 | |
| | Superstructure | 460,300.00 | 1,249,150.00 |
| Hydraulic Equipment | | | 1,254,000.00 |
| Electrical Equipment | | | 2,167,000.00 |
| Miscellaneous | | | 160,000.00 |
| | | | $17,026,476.00 |
| Engineering and Contingencies - 25% | | | 4,256,619.00 |
| Interest During Construction - 7½% | | | 1,276,986.00 |
| | | | $22,560,081.00 |

 Mr. J. Allan Ross.

(Appendix XI-b)

Note: Intake, Entrance Canal, Control Works, Tunnel and Canal are all for 300,000 horse-power. If timbering be required in only half the length of tunnel work, the grand total would be reduced to $21,934,482.00.

This estimate is based on the following unit costs:

Earth excavation at 35 cents per cubic yard.

Rock excavation at $1.10 per cubic yard.

Tunnel at $347.00 per lineal foot for section with timbering.

Tunnel at $276.00 per lineal foot for section without timbering.

ESTIMATE NO. 2. (Appendix XII-a)

## Queenston-Chippawa Power Development

### Summary of Cost
### 150,000 Horse-power Installation

November, 1917.

Combined Tunnel and Canal Project

| | | | |
|---|---|---|---|
| Intake | | | $ 780,460.00 |
| Entrance Canal and Control Works | | | 802,996.00 |
| Tunnel -37'-0", 13,300 lin.ft. (at $347.00) (Including Drain) | | | 4,735,100.00 |
| Canal -Rock Division No. 1 | | 2,333,875.00 | |
| Transition Rock to Whirlpool | | 52,482.00 | |
| Whirlpool Division | | 732,950.00 | |
| Transition Whirlpool to Rock | | 59,272.00 | |
| Rock Division No. 2 | | 986,310.00 | |
| Forebay | | 443,630.00 | 4,659,019.00 |
| Right-of-way | | | 300,000.00 |
| Highway Bridges - Chippawa Highway | | 84,060.00 | |
| Station Morrison Street | | 44,610.00 | |
| Station 297+30 Thorold St. | | 27,130.00 | |
| Station 351+00 Victoria Ave | | 27,990.00 | 183,790.00 |
| Railway Bridges - N.St.C. & T. Arch | | 45,320.00 | |
| G.T.R. (Wabash) Arch | | 43,760.00 | |
| M.C.R. & G.T.R. | | 98,120.00 | 187,200.00 |
| Gate House | | | 219,504.00 |
| Penstocks - Exciter Penstock | | 18,530.00 | |
| No. 1 " | | 63,158.00 | |
| No. 2 " | | 63,585.00 | |
| No. 3 " | | 63,488.00 | 208,761.00 |
| Power House -Substructure | | 698,350.00 | |
| Superstructure | | 345,300.00 | 1,043,650.00 |
| Hydraulic Equipment | | | 885,000.00 |
| Electrical Equipment | | | 1,625,000.00 |
| Miscellaneous | | | 140,000.00 |
| | | | $15,770,480.00 |
| Engineering and Contingencies - 25% | | | 3,942,620.00 |
| Interest During Construction - 7½ | | | 1,182,786.00 |
| | | | $20,895,886.00 |

Note: Intake, Entrance Canal, Control Works, Tunnel and Canal are all for 300,000 horse-power. If timbering be required in only half the length of tunnel work, the grand total would be reduced to $20,270,267.00.

This estimate is based on the following unit costs:

Earth excavation at 35 cents per cubic yard.

Rock excavation at $1.10 per cubic yard.

Tunnel at $347.00 per lineal foot for section with timbering.

Tunnel at $276.00 per lineal foot for section without timbering.

(Appendix XIII)

ESTIMATE NO. 2-A.

Queenston-Chippawa Power Development

Summary of Estimated Quantities and Cost
300,000 Horse-power Installation

Canal Project — January 3, 1919.

| | | |
|---|---|---|
| Total amount of Estimate No. 2 ..... | | $24,216,815.00 |
| Additional rock excavation, 281,000 cu. yards at $1.00 ..... | $281,000.00 | |
| Concrete Lining, 80,000 cu. yards at $12.00 ..... | 960,000.00 | |
| Channelling upper 10 feet of each side, 720,000 sq. ft. at 30 cents ..... | 216,000.00 | |
| Close drilling below channelled section, 3,062,000 sq. ft. at 10 cents ..... | 306,200.00 | |
| Total ..... | $1,763,200.00 | |
| Less cost of completely channelling sides as at first contemplated, 3,781,000 sq. ft. at 30 cents ..... | 1,134,300.00 | |
| Net additional cost ..... | $ 628,900.00 | |
| Add 25% for engineering and contingencies ..... | 157,200.00 | 786,100.00 |
| Total capital cost ..... | | $25,102,915.00 |

Capital cost per horse-power gained = $\frac{786,100}{37,000}$ = $21.25

(Appendix XIV-a)

QUEBEC-ONTARIO POWER DEVELOPMENT

Summary of Estimated Cost by Hugh L. Cooper & Company

mal Project — August 7, 1920.

| | CASE I | | CASE II | | CASE III | |
|---|---|---|---|---|---|---|
| | 5 Units | 9 Units | 5 Units | 9 Units | 5 Units | 9 Units |
| | $ | $ | $ | $ | $ | $ |
| take | 3,359,093 | 3,359,093 | 581,640 | 581,640 | 604,053 | 604,053 |
| lland River | 1,831,434 | 1,831,434 | 644,996 | 1,170,357 | 1,289,071 | 1,920,170 |
| wer Canal | 22,912,732 | 22,912,732 | 22,864,311 | 22,487,182 | 25,685,602 | 26,022,765 |
| rebay | 385,502 | 385,502 | 610,502 | 610,502 | 2,449,795 | 2,449,795 |
| reen House | 1,582,823 | 1,777,398 | 1,549,071 | 1,743,646 | 2,193,122 | 2,493,122 |
| natocks | 1,173,985 | 1,872,573 | 1,173,985 | 1,872,573 | 1,364,766 | 2,532,850 |
| wer House | 5,116,005 | 8,020,424 | 5,116,005 | 8,020,424 | 6,125,120 | 10,582,987 |
| draulic Equip. | 2,009,840 | 3,557,000 | 2,009,840 | 3,557,000 | 2,434,040 | 4,754,780 |
| ectrical Equip. | 4,752,160 | 8,417,360 | 4,752,160 | 8,417,360 | 5,668,460 | 11,166,260 |
| ght-of-Way | | | | | | |
| idges | 1,534,023 | 1,534,023 | 1,534,023 | 1,534,023 | 1,534,023 | 1,534,023 |
| Total | 44,657,600 | 53,667,543 | 40,236,535 | 49,994,710 | 49,348,055 | 64,061,806 |
| gineering and Overhead at 8% | 3,572,608 | 4,293,403 | 3,218,922 | 3,999,576 | 3,947,844 | 5,124,944 |
| Total | 48,230,208 | 57,960,946 | 43,455,457 | 53,994,287 | 53,295,899 | 69,186,751 |
| terest Charges | 4,193,209 | 4,675,984 | 3,407,434 | 4,222,347 | 4,692,726 | 5,743,755 |
| Total | 52,423,418 | 62,636,931 | 46,862,892 | 58,216,635 | 57,988,626 | 74,930,506 |
| tal Disbursements | 14,000,000 | 14,000,000 | 14,000,000 | 14,000,000 | 14,000,000 | 14,000,000 |
| GRAND TOTAL | 66,423,418 | 76,636,931 | 60,862,892 | 72,216,635 | 71,988,626 | 88,930,506 |



Notes:

Cents are omitted in all cases.
Interest Charges are compounded semi-annually at 6-1/2 per cent.
Total Disbursements are to May 1st, 1920, plus interest compounded annually to January 31st, 1923.

## QUEENSTON-CHIPPAWA POWER DEVELOPMENT

## Unit Prices for Estimated Cost by Hugh L. Cooper & Company

Canal Project August 7, 1920.

| ITEM | UNIT | INTAKE | WELLAND RIVER | POWER CANAL | FOREBAY | SCREEN HOUSE | PEN-STOCKS | POWER HOUSE | TESTING WHIRLPOOL SECTION |
|---|---|---|---|---|---|---|---|---|---|
| | | $ | $ | $ | $ | $ | $ | $ | $ |
| Steel Sheet Piling | ton | 125.00 | 0.70 | - | - | - | - | - | - |
| Puddle | c.y. | 1.20 | - | (3.50 & | - | - | - | - | - |
| Rock Excavation | c.y. | 3.50 | - | (5.50 | Complete | - | 3.50 | 3.50 | - |
| Earth Excavation | c.y. | .65 | .70 | 1.10 | Complete | - | - | - | - |
| Concrete Plain | c.y. | 15.00 | 16.00 | 14.00 | 14.00 | - | 16.00 | 15.00 in O. Dams | *20.00 |
| Concrete Reinforced | c.y. | 40.00 | - | 40.00 | - | 40.00 | 40.00 | 32.00 in Foundations | - |
| Structural Steel | lb. | .10 | - | .10 | - | .07½ & .10 | - .11½ | - | - |
| C. I. Spacers | lb. | .15 | - | - | - | - | - | - | - |
| Earth Fill | c.y. | .60 | - | - | - | - | - | - | * .60 |
| Riprap | c.y. | 1.00 | 1.00 | - | - | 3.00 | 3.00 | - | - |
| Rock Lining | | - | - | .15 | - | - | - | - | - |
| Gate Oper. Mach. | lb. | - | - | .40 | - | - | - | - | - |
| Rock Fill | c.y. | - | - | .15 | - | 1.50 | - | - | - |
| Anchor Rods | lb. | - | - | .20 | .20 | - | - | - | - |
| Buildings, Superstr. | c.f. | - | - | - | - | .40 | - | .40 | - |
| Tunnel Rock | c.y. | - | - | - | - | - | 10.00 | - | - |
| Tail Race Excavation | c.y. | - | - | - | - | - | - | 5.50 | - |
| Earth for Piers | c.y. | .65 | - | - | - | - | - | - | - |
| Suction Dredging | | .45 | - | .45 | - | - | - | - | - |
| Caissons, Installing | Each | 3000.00 | - | - | - | - | - | - | - |
| " First Cost | Total | 40000.00 | - | - | - | - | - | - | - |
| Dipper Dredging | c.y. | - | - | .80 | - | - | - | - | - |
| Steam Shovel | | - | - | 1.10 | - | - | - | - | - |



Note:

* These refer to Hugh L. Cooper & Company's figures resulting from their suggested changes in construction methods.

(Appendix XIV-c)

COBALT-CHIPPAWA POWER DEVELOPMENT

Explanation of Estimates of Cost by Hugh L. Cooper & Company

Canal Project August 7, 1920.

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Case I is given as the estimate of cost of the project as designed by the Hydro-Electric Power Commission engineers wherein Hugh L. Cooper & Company's quantities and unit prices have been applied, using 15,000 cubic feet per second of water.

Case II is an estimate of cost of the project wherein Hugh L. Cooper & Company have introduced modifications in design, in accordance with their letter of transmittal dated August 7th, 1920, applied their quantities and unit prices, and used a flow of 15,000 cubic feet per second.



Case III is the same as Case II, but using 20,000 cubic feet per second.

All estimates are of the cost to complete by January 1st, 1923.

(Appendix XV-a)

Queenston-Chippawa Power Development

Summary of Estimated Cost by Messrs. Stuart and Kerbaugh
250,000 Horse-power Installation
With Canal Flow at 15,000 c. f. s.

Canal Project — September 30, 1920.

| Section | Cost to Aug. 26, 1920 | Remaining Cost | Grand Total |
|---|---|---|---|
| 1-Intake | $ 259,578. | $ 1,340,003. | $1,599,581. |
| 2-Welland River | 387,568. | 974,823. | 1,362,391. |
| 3-43A- Canal | 7,071,033. | 16,294,033. | 23,365,056. |
| 4-Forebay | 794,154. | 116,000. | 910,154. |
| 5-Screen House | 97,794. | 976,300. | 1,074,094. |
| 6-Penstocks | 38,628. | 1,052,510. | 1,091,138. |
| 7-Power House | 437,701. | 1,560,000. | 1,997,701. |
| 8-Hydraulic Machinery | - | 1,646,000. | 1,646,000. |
| 9-Right-of-Way | 1,000,000. | - | 1,000,000. |
| Miscellaneous | - | 200,000. | 200,000. |
| Bridges | 909,000. | 1,091,000. | 2,000,000. |
| | $10,995,646. | $25,250,469. | $36,246,115. |
| Contingencies - 10% ..... | | | 3,624,611. |
| Total Net Cost ..... | | | $39,870,726. |
| Estimate of Cost of Superstructure and Electrical Equipment up to L. T. Bus ..... | | | 5,301,033. |
| Estimated residue value of Plant and Stores on hand to finish ..... | | | 4,700,000. |
| Total Investment ..... | | | $49,871,759. |
| Less: Possible Salvage recoverable - $4,000,000. | | | |
| Receipts from Broken Stone - 2,600,000. | | | $ 6,600,000. |
| Total Net Investment ..... | | | $43,271,759. |
| Total Cost per H.P. ..... | | | 173.08 |



Note: For basis of this estimate see Appendix XV-b.

(Appendix XV-b)

Queenston-Chippawa Power Development

Summary of Estimated Cost by Messrs. Stuart and Kerbaugh
450,000 Horse-power Installation
With Canal Flow at 15,000 c. f. s.

Canal Project September 30, 1920.

---

| | |
|---|---|
| Cost of 250,000 H. P. Installation with five units ..... | $43,271,759.00 |
| Additional cost to install units Nos. 6 to 9 ..... | 9,000,000.00 |
| | $52,271,759.00 |
| Total Cost per H. P. ..... | $116.16 |



This estimate was based on the cost data of the work already done, and generally figured on basic prices as follows:

| | |
|---|---|
| Earth excavation ..... | $0.70 per cubic yard, |
| Rock excavation ..... | $2.70 per cubic yard, |
| Plain concrete ..... | $14.50 per cubic yard, |
| Reinforced ..... | $25.00 per cubic yard. |

Mr. J. Allan Ross.

(Appendix XV-c)

Queenston-Chippawa Power Development

Summary of Estimated Costs by Messrs. Stuart and Marbaugh
For Various Horse-power Capacities With Canal
Enlarged for Flow of 22,000 c. f. s.

Canal Project — September 30, 1920.

---

250,000 Horse-power Installation

| | |
|---|---|
| Estimated cost of 250,000 H.P. Installation at 15,000 c. f. s. | $43,271,759.00 |
| Estimated net cost to deepen rock section, less receipts for broken stone | 3,700,000.00 |
| Total Cost | $46,971,759.00 |
| Total Cost per H. P. | $187.89 |



450,000 Horse-power Installation

| | |
|---|---|
| Estimated cost of 450,000 H.P. Installation at 15,000 c. f. s. | $52,271,759.00 |
| Estimated net cost to deepen rock section, less receipts for broken stone | 3,700,000.00 |
| Total Cost | $55,971,759.00 |
| Total Cost per H. P. | $124.38 |

660,000 Horse-power Installation

| | |
|---|---|
| Estimated cost of 450,000 H.P. Installation at 22,000 c. f. s. with nine units | $55,971,759.00 |
| Estimated additional cost of putting in operation three more units | 11,900,000.00 |
| Total Cost | $67,871,759.00 |
| Total Cost per H. P. | $102.83 |

(Appendix XV-d)

Queenston-Chippawa Power Development

Summary of Estimated Cost by Messrs. Stuart and Purbaugh
300,000 Horse-power Installation
Being a Revision of Estimate of September 30, 1920.

Canal Project December 15, 1921.

---

| | |
|---|---|
| Estimate of September 30, 1920 ..... | $43,271,759. |
| Estimate of excess cost over the September, 1920, estimate - | |
| (See page C-53, Chapter C) - "wholly unforeseen items" ..... | 7,403,834. |
| (See page C-57, Chapter C) - "justifiably unforeseen items" | 3,600,000. |
| Total ..... | $54,275,593. |
| Total Cost per Horse-power ..... | $180.92 |

(Appendix XVI-a)

## Queenston-Chippawa Power Development

## Estimated Cost of Complete Project as now partly Constructed.

## Based on 1916 Unit Prices

Canal Project — January 27, 1923.

| Item | Hydraulic Dept. | Electrical Dept. | Total |
|---|---|---|---|
| Intake | 1,130,236 | - | 1,130,236 |
| Welland River | 893,070 | - | 893,070 |
| Canal | 17,523,106 | - | 17,523,106 |
| Forebay | 948,172 | - | 948,172 |
| Screen House | 713,299 | 151,000 | 864,299 |
| Power House | 1,575,412 | 275,529 | 1,850,941 |
| Equipment | 1,430,000 | 3,765,737 | 5,195,737 |
| Penstocks | 565,067 | - | 565,067 |
| Bridges | 1,200,000 | - | 1,200,000 |
| Right-of-Way | 900,000 | - | 900,000 |
| Miscellaneous | 200,000 | - | 200,000 |
| | $ 27,078,362 | $ 4,192,266 | $ 31,270,628 |



Total Estimated Cost of Completed Project as now partly constructed, with five units ..... $ 31,270,628

## Queenston-Chippawa Power Development

## Estimated Cost of Complete Project as now partly Constructed.

## Based on 1916 Unit Prices

Canal Project — January 27, 1923. — Details

| Item | Quantity | Unit Cost | Cost | Total |
|---|---|---|---|---|
| **Intake.** | | | | |
| Sheet Piling | 187,090 ft. | 1.10 | 205,799 | |
| Fill | 139,120 cu.yds. | .25 | 34,780 | |
| Pumping | - | - | 20,000 | |
| Earth Excavation | 617,067 cu.yds. | .50 | 308,534 | |
| Rock Excavation | 25,470 cu.yds. | 2.50 | 63,675 | |
| Earth Fill | 81,000 cu.yds. | .20 | 16,200 | |
| Rip-rap | 15,000 sq.yds. | 1.00 | 15,000 | |
| Concrete | 32,000 cu.yds. | 10.00 | 320,000 | |
| Reinforcing Steel | 960,000 lbs. | .05 | 48,000 | |
| Cast Iron and Steel | 140,000 lbs. | .06 | 8,400 | |
| Gates - Intake | 468,400 lbs. | .07 | 32,788 | |
| Timber in Cribs | 437,670 ft. | 60.00 | 26,260 | |
| Iron in Cribs | 15,000 lbs. | .05 | 800 | |
| Removal of Coffordam | | | 30,000 | $ 1,130,236 |
| **Welland River.** | | | | |
| Earth Excavation | 2,132,674 cu.yds. | .40 | 853,070 | |
| Rip-rap | 25,000 cu.yds. | 1.00 | 25,000 | |
| Concrete | 1,500 cu.yds. | 10.00 | 15,000 | $ 893,070 |
| **Canal.** | | | | |
| Dredging | 1,856,070 cu.yds. | .40 | 742,428 | |
| Earth Excavation | 9,651,557 cu.yds. | .50 | 4,825,779 | |
| Rock Excavation | 3,841,247 cu.yds. | 2.00 | 7,682,494 | |
| Concrete Lining and Walls | 304,299 cu.yds. | 12.00 | 3,651,588 | |
| Rip-rap and Rock Fill | 968,028 cu.yds. | .60 | 580,817 | |
| Structural Steel and Gates | - | - | 40,000 | $ 17,523,106 |
| Carried Forward | | | | $ 19,546,412 |

Canal Project — Details (Continued)

| Item | Quantity | Unit Cost | Cost | Total |
|---|---|---|---|---|
| Brought Forward ..... | | | | $ 19,546,412 |
| **Forebay.** | | | | |
| Earth Excavation ..... | 49,080 cu.yds.. | .50 ... | 24,540 | |
| Rock Excavation ..... | 472,590 cu.yds.. | 1.75 ... | 827,032 | |
| Concrete and Gunite ..... | 6,440 cu.yds.. | 15.00 ... | 96,600 | $ 948,172 |
| **Screen House.** | | | | |
| Earth Excavation ..... | 1,526 cu.yds.. | .80 ... | 1,221 | |
| Rock Excavation ..... | 43,470 cu.yds.. | 2.50 ... | 108,675 | |
| Concrete, Reinforced ..... | 29,712 cu.yds.. | 15.00 ... | 445,680 | |
| Structural Steel, Racks and Gates ..... | 1,971,[illegible] lbs..... | .08 ... | 157,723 | $ 713,299 |
| **Penstocks.** | | | | |
| Rock Excavation ..... | 18,791 cu.yds.. | 5.00 ... | 93,955 | |
| Concrete / Facing Concrete ..... | 18,919 cu.yds.. | 8.00 ... | 151,352 | |
| Steel ..... | 4,568,000 lbs..... | .07 ... | 319,760 | $ 565,067 |
| **Power House.** | | | | |
| Talus Excavation ..... | 22,790 cu.yds.. | .70 ... | 15,953 | |
| Rock Excavation ..... | 341,273 cu.yds.. | 2.50 ... | 853,183 | |
| Concrete ..... | 55,823 cu.yds.. | 12.00 ... | 669,876 | |
| Structural Steel ..... | 520,000 lbs..... | .07 ... | 36,400 | $ 1,575,412 |
| **Hydraulic Equipment.** | | | | |
| Johnson Valves ..... | - ..... | - ... | 300,000 | |
| Draft Tubes ..... | - ..... | - ... | 10,000 | |
| Units, 5 Main and 2 Service | - ..... | - .. | 1,120,000 | $ 1,430,000 |
| Right-of-Way ..... | - ..... | - ... | 900,000 | $ 900,000 |
| Miscellaneous ..... | - ..... | - ... | 200,000 | $ 200,000 |
| Bridges ..... | - ..... | - .. | 1,200,000 | $ 1,200,000 |
| | | | | $ 27,078,362 |

Mr. J. Allan Ross.

(Appendix XVII-a)

## Queenston-Chippawa Power Development

## Estimated Cost of Completed Development as designed in 1917

## Based on 1916 Unit Prices

Canal Project. January 27, 1923.

| Item | Hydraulic Dept. | Electrical Dept. | Total |
|---|---|---|---|
| Intake | 977,440 | - | 977,440 |
| Welland River | 1,026,785 | - | 1,026,785 |
| Canal | 14,085,725 | - | 14,085,725 |
| Screen House | 351,110 | 180,000 | 531,110 |
| Penstocks | 468,650 | - | 468,650 |
| Power House | 1,272,900 | 506,000 | 1,778,900 |
| Equipment | 1,768,000 | 3,795,000 | 5,563,000 |
| Bridges | 809,388 | - | 809,388 |
| Right-of-Way | 600,000 | - | 600,000 |
| Miscellaneous | 175,000 | - | 175,000 |
| | $ 21,534,998 | $ 4,481,000 | $ 26,015,998 |



Total estimated Cost of Completed Project as designed in 1917, with five units ..... $ 26,015,998

(Appendix XVII-b)

Queenston-Chippawa Power Development

Estimated Cost of Completed Development as designed in 1917.

Based on 1916 Unit Prices

Canal Project — January 27, 1923. — Details

| Item | Quantity | Unit Cost | Cost | Total |
|---|---|---|---|---|
| **Intake.** | | | | |
| Coffordams | 1980 lin.ft. | at $92 | 182,160 | |
| Pumping | | | 20,000 | |
| Excavation | 427,000 cu.yds. | at 50¢ | 213,500 | |
| Concrete | 469,000 cu.yds. | at $10 | 469,000 | |
| Reinforcing Steel | 626,000 lbs. | at 5¢ | 31,300 | |
| Steel Plate | 57,600 lbs. | at 7¢ | 4,040 | |
| Light House for Chippawa Light | | | 8,000 | |
| Sluice Gates | | | 10,000 | |
| Gates for Ship Channel | | | 30,000 | |
| Piling | 13,250 lin.ft. | at 35¢ | 4,640 | |
| Lumber | 80,000 f.b.m. | at $60 | 4,800 | 977,440 |
| **Welland River.** | | | | |
| Dredging | 2,053,000 cu.yds. | at 40¢ | 1,001,600 | |
| Rip-rap | 17,600 cu.yds. | at $1 | 17,600 | |
| Concrete | 700 cu.yds. | at $10 | 7,000 | |
| Reinforcing Steel | 11,700 lbs. | at 5¢ | 585 | 1,026,785 |
| **Canal.** | | | | |
| Dredging | 282,000 cu.yds. | at 40¢ | 112,800 | |
| Earth Excavation | 8,959,150 cu.yds. | at 50¢ | 4,479,575 | |
| Rock Excavation | 3,503,850 cu.yds. | at $2 | 7,007,700 | |
| Concrete | 175,203 cu.yds. | at $12 | 2,102,436 | |
| Rip-rap | 191,440 cu.yds. | at 60¢ | 114,864 | |
| Structural Steel and Gates (2 Gates) | - | | 30,000 | |
| Superstructure for Gates | 144,000 cu.ft. | at 12¢ | 17,280 | |
| Piling | 20,000 lin.ft. | at 35¢ | 7,000 | |
| Reinforcing Steel | 4,281,400 lbs. | at 5¢ | 214,070 | 14,085,725 |
| Carried Forward | | | | $ 16,089,950 |

Canal Project — Details (continued)

| Item | Quantity | Unit Cost | Cost | Total |
|---|---|---|---|---|
| Brought Forward ..... | | | | $16,089,950 |
| Bridges ..... | | | | 809,388 |
| Right-of-Way ..... | | | | 600,000 |
| **Gate House.** | | | | |
| Rock Excavation ..... | 23,500 cu.yds. | at $2.50 | 58,750 | |
| Concrete, Reinforced ..... | 3,000 cu.yds. | at $15 | 45,000 | |
| Concrete, Plain ..... | 10,000 cu.yds. | at $12 | 120,000 | |
| Reinforcing Steel ..... | 320,000 lbs. | at 5¢ | 16,000 | |
| Structural Steel and Racks ... | 402,000 lbs. | at 8¢ | 32,160 | |
| **Ice Chute.** | | | | |
| Concrete ..... | 965 cu.yds. | at $8 | 7,720 | |
| Steel ..... | 164,000 lbs. | at 7¢ | 11,480 | |
| Gates ..... | 8 at $10,000 | ea. | 60,000 | 351,110 |
| **Penstocks.** | | | | |
| Tunnel Excavation ..... | 5,760 cu.yds. | at $10 | 57,600 | |
| Rock Excavation ..... | 11,500 cu.yds. | at $5 | 57,500 | |
| Steel Work ..... | 4,365,000 lbs. | at 7¢ | 305,550 | |
| Concrete ..... | 8,500 cu.yds. | at $8 | 68,000 | 468,650 |
| **Power House Substructure.** | | | | |
| Unwatering ..... | | | 50,000 | |
| Talus Excavation ..... | 219,500 cu.yds. | at 70¢ | 153,650 | |
| Rock Excavation ..... | 104,900 cu.yds. | at $2.50 | 262,250 | |
| Concrete in Substructure ..... | 66,000 cu.yds. | at $12 | 792,000 | |
| Reinforcing Steel ..... | 300,000 lbs. | at 5¢ | 15,000 | 1,272,900 |
| Hydraulic Equipment ..... | | | | 1,760,000 |
| Miscellaneous ..... | | | | 175,000 |
| | | | | $21,534,998 |

WALTER J. FRANCIS & COMPANY.

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(Appendix XVIII)

Queenston-Chippawa Power Development

Estimated Cost of Complete Project with Five Units

Canal Project January 29, 1923.

---

Hydraulic Department

| | | |
|---|---|---|
| Expenditures to March 31st, 1922 ..... | $ | 53,180,693 |
| Estimated cost of completion of Units #1 to #5 ..... | | 3,981,114 |
| Overhead expenses on above estimate ..... | | 486,342 |
| Interest accrued and not charged to operation ..... | | 1,704,815 |



Electrical Department

| | | |
|---|---|---|
| Electrical machines and power house superstructure for Units #1 to #5 ..... | | 4,646,029 |
| Screen house superstructure ..... | | 371,187 |
| Estimated cost of complete project with five units | $ | 64,370,180 |

Note: The residual value of the construction plant on the completion of #5 Unit is estimated at $3,774,000, the balance of the construction plant cost being included in the above estimate.

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(Appendix XIX)

Queenston-Chippawa Power Development

Estimated Cost of Complete Project with Nine Units

Canal Project January 29, 1923.

---

Hydraulic Department

| | |
|---|---|
| Expenditure to March 31st, 1922 | $ 53,180,693 |
| Estimated cost of completion of Units #1 to #5 | 3,981,114 |
| Overhead expenses on above estimate | 486,342 |
| Interest accrued and not charged to operation | 1,704,815 |
| Additional estimated cost, Unit #6 | 1,414,271 |
| Additional estimated cost, Unit #7 | 1,495,441 |
| Additional estimated cost, Unit #8 | 1,563,479 |
| Additional estimated cost, Unit #9 | 1,633,996 |



Electrical Department

| | |
|---|---|
| Electrical machines and power house superstructure for Units #1 to #5 | 4,646,029 |
| Screen House superstructure | 371,187 |
| Estimated cost electrical machine, Unit #6 | 1,000,000 |
| Screen House superstructure for Unit #6 | 20,000 |
| Estimated cost electrical machine, Unit #7 | 1,000,000 |
| Screen House superstructure for Unit #7 | 60,000 |
| Estimated cost electrical machine, Unit #8 | 1,000,000 |
| Screen House superstructure for Unit #8 | 60,000 |
| Estimated cost electrical machine, Unit #9 | 1,000,000 |
| Screen House superstructure for Unit #9 | 60,000 |
| Estimated cost of complete project with nine units | $ 74,677,367 |

Note: The residual value of the construction plant on the completion of #9 Unit is estimated at $3,041,100, the balance of the construction plant cost being included in the above estimate.

WALTER J. FRANCIS & COMPANY.

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Queenston-Chippawa Power Development

Estimated Cost of Complete Project with Ten Units

Canal Project January 29, 1923.

| | |
|---|---|
| Estimated cost to complete project with nine units ..... | $ 74,677,367 |
| Hydraulic Department, estimated cost of #10 Unit and cleaning up ..... | 4,641,647 |
| Electrical Department, estimated cost of #10 Unit ..... | 1,410,000 |
| Estimated cost of complete project with ten units | $ 80,729,014 |

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Note: The residual value of the construction plant on the completion of #10 Unit is estimated at $2,487,100, the balance of the construction plant cost being included in the above estimate.

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Schedule 1

Summary of Expenditures and Accrued Liabilities, together

---

CASH PAYMENTS.

Total expenditure on Hydraulic Works and Generating Plant to March 31st,19

ACCRUED LIABILITIES.

Interest accrued but unpaid for 5 months ending March 31st,1922 .....

Less estimated net revenue obtained from operation of Plant to March 31st,

Commitments on Contracts to March 31st,1922 .....

Contingent Liabilities as at March 31st, 1922 .....

Total Cash Payments, Accrued Liabilities, Commitments on Contracts and Contingent Liabilities to March 31st,1922 .....

COPY

ALLOCATED.

Against Permanent Works - Schedule 2 - .....

Construction Plant and Miscellaneous Operating Expenses carried forward as part of costs of completing work - Schedule 3 - .....

Stores on hand - Schedule 4 - .....

Head Office Expenses together with Interest paid to October 31st,1921 plus Interest accrued but unpaid at this date, for 5 months ending March 31st,1922 .....

Less amount charged against permanent works as an overhead - Schedule 5 -

Less Engineering Costs distributed in excess of expenditures - Schedule 6 -

Add Commitments on Contracts to March 31st,1922, not allocated .....

and Contingent Liabilities as at March 31st,1922 .....

WALTER J. FRANCIS & COMPANY.

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(Appendix XXI-a)

POWER DEVELOPMENT

with allocation of same, as at March 31st, 1922.

---

| | | |
|---|---|---|
| ..... | | $ 60,826,061.52 |
| ... $ 1,549,125.34 | | |
| ... 192,975.70 ... $ | 1,356,149.64 | |
| ..... | 1,170,918.67 | |
| ..... | 43,676.27 .... | 2,570,744.58 |
| COPY | | |
| ..... | | $ 63,396,805.90 |
| ..... | 56,795,126.16 | |
| ..... | 3,054,422.65 | |
| ..... | 1,626,560.73 | |
| ... 7,654,169.51 | | |
| ... 6,943,566.89 ..... | 710,602.62 | |
| | 62,186,712.16 | |
| ..... | 4,501.20 | |
| | 62,182,210.96 | |
| ..... | 1,170,918.67 | |
| ..... | 43,676.27 | $ 63,396,805.90 |

CHEMISTON-CHIPPAWA

Schedule 2

Allocation of Expenditures

| Item | |
|---|---|
| Intake Works | |
| River Improvements | |
| Ice and Log Chutes | |
| Penstocks, including work on Escarpment | |
| Power House - General | |
| Power House - Substructure | |
| Power House - Machinery and Miscellaneous Supply Systems | |
| Power House, Office Houses - Permanent | |
| Turbines and Governors - Main | |
| Bridges, Trestles, Culverts and Roadways | |
| Forebay | |
| Headworks - General | |
| Headworks - Substructure | |
| Headworks - Superstructure | |
| Elevator Shaft and Tunnels | |
| Permanent Railways | |
| Right-of-Way | |
| Canal | |
| Total Cost of Hydraulic Construction Works | |
| Generating Station Equipment and portion of Power House Superstructure | |



# Overhead comprises Construction Plant Operation, Earth and Ro
Expense, Engineering and Administrative Expenses and Interest

WALTER J. FRANCIS & COMPANY.

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(Appendix XXI-b)

POWER DEVELOPMENT

against Permanent Works

| | Material | Labour | Overhead | Total |
|---|---|---|---|---|
| ... | $ 182,874.82 ..... | $ 235,277.29 .... | $ 629,650.20 .... | $ 1,045,782.31 |
| ... | 195,726.26 ..... | 248,914.72 .... | 616,448.15 .... | 1,059,089.13 |
| ... | 35,108.15 ..... | 14,878.82 .... | 20,088.08 .... | 70,075.05 |
| ... | 589,874.64 ..... | 142,419.96 .... | 273,825.85 .... | 1,006,120.45 |
| ... | 133,937.50 ..... | 498,067.23 .... | 751,400.84 .... | 1,383,405.57 |
| ... | 547,520.65 ..... | 416,294.52 .... | 632,541.64 .... | 1,596,356.81 |
| ... | 339,319.40 ..... | 29,269.12 .... | 55,677.09 .... | 424,265.61 |
| ... | 2,858.46 ..... | 7,826.98 .... | 5,865.50 .... | 15,970.69 |
| ... | 1,114,169.62 ..... | 41,974.96 .... | 159,406.93 .... | 1,315,551.51 |
| ... | 820,946.53 ..... | 742,753.09 .... | 762,637.02 .... | 2,326,336.64 |
| ... | 228,908.60 ..... | 292,004.64 .... | 750,391.21 .... | 1,271,334.45 |
| ... | 74,555.42 ..... | 93,026.66 .... | 52,326.05 .... | 219,683.13 |
| ... | 600,639.39 ..... | 345,544.47 .... | 474,319.77 .... | 1,420,503.63 |
| ... | 92,660.30 ..... | 46,026.36 .... | 49,421.76 .... | 188,108.44 |
| ... | 10,460.68 ..... | 44,714.48 .... | 43,049.09 .... | 98,224.25 |
| ... | - ..... | - .... | 200,000.00 .... | 200,000.00 |
| ... | 1,490,859.08 ..... | - .... | Cr. (340.93) .... | 1,490,518.15 |
| ... | 6,007,719.16 ..... | 7,821,594.79 .... | 24,855,750.63 .... | 38,685,064.58 |
| ... | $ 12,475,916.66 .... | $ 11,018,615.04 ... | $ 30,351,858.90 ... | $ 53,824,390.60 |
| ... | 2,215,612.06 .... | 308,395.49 ... | 446,728.01 ... | 2,970,735.56 |
| | $ 14,689,528.72 | $ 11,327,010.53 | $ 30,778,586.91 | $ 56,795,126.16 |

WALTER J. FRANCIS & COMPANY.

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Schedule 3

Allocation of Construction Plant and

| Item | Material and Plant |
|---|---|
| CONSTRUCTION PLANT. | |
| Construction Plant, Machinery and Small Tools | $ 9,382,487.02 |
| Temporary Buildings | 1,278,097.40 |
| Construction Railways | 2,620,441.67 |
| Construction Roadways | 93,630.58 |
| Power, Light and Telephone Lines | 767,559.02 |
| | $ 14,142,215.69 |
| MISCELLANEOUS OPERATING EXPENSES. | |
| Water and Sanitary Systems - Temporary | 21,582.47 |
| Compressed Air System Operation | 3,590.93 |
| Construction Plant Maintenance | 2,478,745.64 |
| Auxiliary Plant Operation | 2,149,499.89 |
| Tests and Inspection | 9,283.16 |
| Salvaging and overhauling of Plant and Material ( other than Stores) for the purpose of re-sale, Balance of Cost to March 31st,1922 | - |
| | $ 18,804,915.78 |

COPY

Statement of

Schedule 4

Stores on hand March 31st,1922 .....

(Appendix XXI-c)

POWER DEVELOPMENT

Miscellaneous Operating Expenses

| | Labour | Total | Charged against Permanent Works to March 31st, 1922 | Carried forwar against cost of completion of work and for salvage |
|---|---|---|---|---|
| ... | $ 959,728.08 ..... | $ 10,342,215.10 ..... | $ 8,060,763.41 ..... | $ 2,281,451.69 |
| ... | 651,270.66 ..... | 1,929,368.06 ..... | 1,776,606.97 ..... | 150,761.09 |
| ... | 758,111.44 ..... | 3,376,553.11 ..... | 2,983,715.95 ..... | 394,837.16 |
| ... | 56,895.64 ..... | 130,526.22 ..... | 131,238.00 .....Cr. | 711.78 |
| ... | 95,242.95 ..... | 862,801.97 ..... | 731,022.83 ..... | 131,779.14 |
| ... | $ 2,501,248.77 ..... | $ 16,643,464.45 ..... | $ 13,685,347.16 ..... | $ 2,958,117.30 |
| ... | 45,351.75 ..... | 66,934.22 ..... | 66,934.22 ..... | - |
| ... | 534.38 ..... | 4,115.31 ..... | - ..... | 4,115.31 |
| ... | 1,784,236.42 ..... | 4,262,980.06 ..... | 4,262,980.06 ..... | - |
| ... | 3,360,069.27 ..... | 5,509,569.16 ..... | 5,525,004.67 ..... | 15,435.51 |
| ... | 28,418.45 ..... | 57,701.53 ..... | 56,728.62 ..... | 972.91 |
| ... | 106,652.64 ..... | 106,652.64 ..... | - ..... | 106,652.64 |
| | $ 7,826,501.66 | $ 26,651,417.38 | $ 23,576,994.73 | $ 3,054,422.65 |



Stores on hand ..... $ 1,626,560.73

Schedule 5

Allocation of Head Office

| Item | Total Expense to March 31st, 1922 |
|---|---|
| Administration Charges | $ 1,177,607.05 |
| Interest during Construction | 5,947,282.10 |
| Preliminary Surveys | 43,302.69 |
| Insurance and Taxes | 379,365.36 |
| Business and Legal | 14,386.19 |
| Head Office Engineering Expenses | 40,395.72 |
| Expenses securing Labour | 39,202.01 |
| Postage, Telephone and Telegraph | 12,630.21 |
| | $ 7,654,169.31 |



Summary.

| | |
|---|---|
| Total expenditure to March 31st, 1922 | |
| Charged as Overhead in work to March 31st, 1922 | |
| Add undistributed Interest | $ 716,246.89 |
| Less items distributed in excess of expenditures | 5,644.27 |

WALTER J. FRANCIS & COMPANY.

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(Appendix XXI-d)

POWER DEVELOPMENT

Expenses and Interest

| | Written off as an Overhead | Expenses Carried Forward against costs of completion of work | Interest |
|---|---|---|---|
| ... | $ 1,181,253.64 ..... | Cr. $ 3,646.61 ..... | - |
| ... | 5,251,035.21 ..... | - ..... | 716,246.89 |
| ... | 45,302.69 ..... | - ..... | - |
| ... | 361,598.38 ..... | Cr. 2,223.02 ..... | - |
| ... | 14,386.19 ..... | - ..... | - |
| ... | 40,076.22 ..... | Dr. 317.50 ..... | - |
| ... | 39,202.01 ..... | - ..... | - |
| ... | 12,722.35 ..... | Cr. 92.14 ..... | - |
| | $ 6,945,566.69 | Cr. $ 5,644.27 | $ 716,246.89 |



..... ..... ..... $ 7,654,169.31

.....$ 6,943,566.69

..... 710,602.62 $ 7,654,169.31

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Schedule 6

[illegible]

Allocation o

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Item

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Head Office Engineering and Superintendence .....

Field Office Engineering and Superintendence .....

Head Office and Field - Designing .....

Engineering, Timekeeping and Accounting .....

Surveys before and during Construction .....

Blue Prints and Photographs .....

Maintenance and Repairs to Instruments .....

Field Office Furniture and Equipment .....

Stationery Supplies for Field Office .....

Field Office Maintenance, Fuel, etc. .....

Camp and Field Equipment .....

Police Protection .....

Fire Protection .....



Summary.

Costs to March 31st, 192[illegible] .....

Charged as Overhead to March 31st, 192[illegible] .....

Deduct items distributed in excess of expenditures .....

WALTER J. FRANCIS & COMPANY.

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(Appendix XXI-e)

POWER DEVELOPMENT

Engineering Costs

| | Expended to March 31st, 1922 | Written off as an Overhead to March 31st, 1922 | Expenses Carried Forward against costs of completion of work |
|---|---|---|---|
| ... | $ 251,574.27 ..... | $ 258,171.18 ..... | Cr.$ 6,596.91 |
| ... | 999,532.82 ..... | 997,782.66 ..... | 1,750.16 |
| ... | 260,662.89 ..... | 257,733.77 ..... | 2,929.12 |
| ... | 305,749.15 ..... | 308,653.38 ..... | Cr. 2,904.23 |
| ... | 73,430.23 ..... | 74,085.69 ..... | Cr. 655.46 |
| ... | 30,419.10 ..... | 29,459.99 ..... | 959.11 |
| ... | 7,100.89 ..... | 7,100.89 ..... | - |
| .. | 40,393.91 ..... | 40,471.17 ..... | Cr. 77.26 |
| ... | 20,699.54 ..... | 20,625.51 ..... | 74.03 |
| ... | 30,445.36 ..... | 30,436.13 ..... | 9.23 |
| ... | 103.19 ..... | 103.19 ..... | - |
| ... | 1,726.90 ..... | 1,726.89 ..... | .01 |
| ... | 37,155.95 ..... | 37,164.95 ..... | Cr. 9.00 |
| | $ 2,058,994.20 | $ 2,063,495.40 | Cr.$ 4,501.20 |



..... $ 2,058,994.20

..... $ 2,063,495.40

..... 4,501.20 ..... $ 2,058,994.20